

UNCLASSIFIED

AD NUMBER

AD836963

LIMITATION CHANGES

TO:

Approved for public release; distribution is unlimited.

FROM:

Distribution authorized to U.S. Gov't. agencies and their contractors;
Administrative/Operational Use; JUL 1968. Other requests shall be referred to OOAMA (OOYEC)
Hill AFB, UT 84401.

AUTHORITY

AEDC ltr 22 Jul 1971

THIS PAGE IS UNCLASSIFIED

Cy!

**STATIC STABILITY CHARACTERISTICS OF
THE M-117 BOMB AT MACH NUMBERS
FROM 0.60 TO 1.40 WITH THREE
TAIL FIN CONFIGURATIONS**



**M. L. Homan
ARO, Inc.**

July 1968

~~This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of OQAMA (OOYEC), HHH AFB, Utah 84401.~~

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION
UNLIMITED (PER DDC-TAB-71-21, 1 Nov 71)

**PROPULSION WIND TUNNEL FACILITY
ARNOLD ENGINEERING DEVELOPMENT CENTER
AIR FORCE SYSTEMS COMMAND
ARNOLD AIR FORCE STATION, TENNESSEE**

AEDC TECHNICAL LIBRARY



5 0720 00031 7802

PROPERTY OF U. S. AIR FORCE
AEDC LIBRARY
F40600-69-C-0001

NOTICES

When U. S. Government drawings specifications, or other data are used for any purpose other than a definitely related Government procurement operation, the Government thereby incurs no responsibility nor any obligation whatsoever, and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise, or in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Qualified users may obtain copies of this report from the Defense Documentation Center.

References to named commercial products in this report are not to be considered in any sense as an endorsement of the product by the United States Air Force or the Government.

ERRATA

AEDC-TR-68-162, July 1968
(Unclassified Report)

STATIC STABILITY CHARACTERISTICS OF
THE M-117 BOMB AT MACH NUMBERS
FROM 0.60 TO 1.40 WITH THREE
TAIL FIN CONFIGURATIONS

M. L. Homan, ARO, Inc.

Arnold Engineering Development Center
Air Force Systems Command
Arnold Air Force Station, Tennessee

- p. 31 Fig. 13 Variation of Induced Side-Force Coefficient
with Angle of Attack

Negative ordinate scale is -4 per division

Negative ordinate scale should be -0.4 per division

- p. 33 Fig. 15 Variation of Induced Rolling-Moment
Coefficient with Angle of Attack

Ordinate scale is 0.4 per division

Ordinate scale should be 0.04 per division

STATIC STABILITY CHARACTERISTICS OF
THE M-117 BOMB AT MACH NUMBERS
FROM 0.60 TO 1.40 WITH THREE
TAIL FIN CONFIGURATIONS

M. L. Homan
ARO, Inc.

~~This document is subject to special export controls
and each transmittal to foreign governments or foreign
nationals may be made only with prior approval of
COMA (OOPEC), Hill AFB, Utah 84401.~~

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION
UNLIMITED (PER DDC-TAB-71-21, 1 Nov 71)

FOREWORD

The work reported herein was done at the request of the Air Force Logistics Command for Picatinny Arsenal, U. S. Army, under Program Area 6441514F.

The results of the test were obtained by ARO, Inc. (a subsidiary of Sverdrup & Parcel and Associates, Inc.), contract operator of the Arnold Engineering Development Center (AEDC), AFSC, Arnold Air Force Station, Tennessee, under Contract F40600-69-C-0001. The test was conducted from April 29 to May 10, 1968, under ARO Project No. PB0868, and the manuscript was submitted for publication on June 24, 1968.

Information in this report is embargoed under the Department of State International Traffic in Arms Regulations. This report may be released to foreign governments by departments or agencies of the U. S. Government subject to approval of OOAMA (OOYEC), Hill AFB, Utah 84401, or higher authority within the Department of the Air Force. Private individuals require a Department of State export license.

This technical report has been reviewed and is approved.

Richard W. Bradley
Lt Colonel, USAF
AF Representative, PWT
Directorate of Test

Roy R. Croy, Jr.
Colonel, USAF
Director of Test

ABSTRACT

A test was conducted in the Propulsion Wind Tunnel (16T) to determine the static stability characteristics of the M-117 Bomb with any of three tail fin configurations. Tests were made over the Mach number range of 0.6 to 1.4 for an angle-of-attack range of -3 to 19 deg, and fin orientations of 11.25 to -101.25 deg. The M-117 Bomb was statically stable for all three tail fin configurations for the Mach number range of the tests.

This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of OOAMA (OOYEC), Hill AFB, Utah 84401.

CONTENTS

| | <u>Page</u> |
|---|-------------|
| ABSTRACT | iii |
| NOMENCLATURE | vii |
| I. INTRODUCTION | 1 |
| II. APPARATUS | |
| 2.1 Test Facilities | 1 |
| 2.2 Model Geometry. | 1 |
| 2.3 Instrumentation | 2 |
| III. TEST DESCRIPTION | |
| 3.1 Procedure | 2 |
| 3.2 Data Reduction | 2 |
| 3.3 Precision of Measurements. | 2 |
| IV. RESULTS AND DISCUSSION | |
| 4.1 Static Stability (Zero-degree Fin Orientation). | 3 |
| 4.2 Fin Orientation | 3 |
| 4.3 Axial Force. | 5 |
| V. CONCLUDING REMARKS. | 5 |
| REFERENCES | 5 |

APPENDIX

Illustrations

Figure

| | |
|---|----|
| 1. Location of Model in Test Section | 9 |
| 2. Model Details | |
| a. M-117 Bomb with M131A1 Fin. | 10 |
| b. M131A1 (Modified Shape) | 11 |
| c. MAU-103A/B | 11 |
| 3. Model Installed in the Test Section | 12 |
| 4. Reynolds Number versus Mach Number | 13 |
| 5. Variation of Normal-Force Coefficient with Angle of Attack, $\gamma = 0$ deg | |
| a. M131A1. | 14 |
| b. MAU-103A/B | 15 |
| c. M131A1 (Modified Shape) | 16 |

| <u>Figure</u> | <u>Page</u> |
|---|-------------|
| 6. Variation of Pitching-Moment Coefficient with Angle of Attack, $\gamma = 0$ deg | |
| a. M131A1 | 17 |
| b. MAU-103A/B | 18 |
| c. M131A1 (Modified Shape) | 19 |
| 7. Static Stability Characteristics, $\gamma = 0$ deg | |
| a. M131A1 | 20 |
| b. MAU-103A/B | 21 |
| c. M131A1 (Modified Shape) | 22 |
| 8. Variation of Neutral-Point Location with Mach Number, $\gamma = 0$ deg | 23 |
| 9. Effect of Fin Orientation on Normal-Force Coefficient | |
| a. M131A1 | 24 |
| b. MAU-103A/B | 25 |
| 10. Effect of Fin Orientation on Pitching-Moment Coefficient | |
| a. M131A1 | 26 |
| b. MAU-103A/B | 27 |
| 11. Effect of Fin Orientation on the Static Stability Characteristics | |
| a. M131A1 | 28 |
| b. MAU-103A/B | 29 |
| 12. Effect of Fin Orientation on Neutral-Point Location | 30 |
| 13. Variation of Induced Side-Force Coefficient with Angle of Attack | 31 |
| 14. Variation of Induced Yawing-Moment Coefficient with Angle of Attack | 32 |
| 15. Variation of Induced Rolling-Moment Coefficient with Angle of Attack | 33 |
| 16. Variation of Axial-Force Coefficient with Mach Number, $\alpha = 0$ | 34 |

NOMENCLATURE

| | |
|------------|---|
| C_A | Axial-force coefficient, positive downstream, $\frac{F_A}{q_\infty S}$ |
| C_ℓ | Rolling-moment coefficient, positive clockwise looking upstream, $\frac{M_\ell}{q_\infty SD}$ |
| C_m | Pitching-moment coefficient, positive nose up, $\frac{M_m}{q_\infty SD}$ |
| C_N | Normal-force coefficient, positive up, $\frac{F_N}{q_\infty S}$ |
| C_n | Yawing-moment coefficient, positive nose right looking upstream, $\frac{M_n}{q_\infty SD}$ |
| C_Y | Side-force coefficient, positive right looking upstream, $\frac{F_Y}{q_\infty S}$ |
| D | Diameter of model (reference diameter), 1.33 ft |
| F_A | Axial force, positive downstream, lb |
| F_N | Normal force, positive up, lb |
| F_Y | Side force, positive right, lb |
| M_ℓ | Rolling moment, positive clockwise looking upstream, ft-lb |
| M_m | Pitching moment, positive nose up, ft-lb |
| M_n | Yawing moment, positive nose right looking upstream, ft-lb |
| M_∞ | Free-stream Mach number |
| q_∞ | Free-stream dynamic pressure, psf |
| Re | Unit Reynolds number, per ft |
| S | Maximum cross-sectional area of model, 1.396 ft ² |
| x_{np} | Neutral-point location expressed in body diameters from the cg, dC_m/dC_N at $\alpha = 0$, positive forward of the cg location |
| α | Model angle of attack, positive nose up, deg |
| γ | Tail fin orientation, positive clockwise looking upstream (zero with one set of fins in the pitch plane), deg |

SECTION I INTRODUCTION

Small-scale tests reported in Ref. 1 were conducted to determine the static stability characteristics of various tail fin configurations proposed for the M-117 Bomb in order to provide both an aerodynamically and structurally acceptable fin. Selections were made from this effort to verify performance full scale. This report presents the results of wind tunnel tests on full-scale M-117 model configurations to determine the static stability characteristics with the original tail fin (M131A1) and two proposed configurations (MAU-103A/B and M131A1 modified).

Tests were made over the Mach number range of 0.6 to 1.4 for an angle-of-attack range of -3 to 19 deg. The tail fin assembly was rotated about the model body longitudinal axis to obtain fin orientations from 11.25 to -101.25 deg.

SECTION II APPARATUS

2.1 TEST FACILITIES

Tunnel 16T is a closed-circuit, continuous-flow wind tunnel that can be operated at Mach numbers from 0.55 to 1.60. The tunnel can be operated over a stagnation pressure range from approximately 100 to 4000 psfa and over a stagnation temperature range from 90 to 125°F. The tunnel specific humidity is controlled by interchanging the tunnel air with conditioned makeup air from an atmospheric dryer. Perforated walls in the test section allow continuous operation through the Mach number range with a minimum of wall interference.

A detailed description of the tunnel, its equipment, and calibration may be found in Ref. 2. Details of the test section wall configuration and location of the model in the tunnel are shown in Fig. 1.

2.2 MODEL GEOMETRY

The test article was a full-scale model of the M-117 Bomb. The basic bomb consisted of a contoured nose section, cylindrical mid-section, and a conical afterbody with four fins spaced at 90-deg intervals. Provisions were made to manually rotate the tail fin assembly

about the model longitudinal axis to obtain fin orientations of 11.25-deg increments. Details of the model and the tail fin configurations are shown in Fig. 2. A typical model installation in the tunnel is shown in Fig. 3.

2.3 INSTRUMENTATION

An internally mounted, six-component, strain-gage balance was used to measure model forces and moments. Outputs from the balance were digitized for on-line data reduction by a Raytheon 520 computer. Also, the balance outputs were continuously recorded on a direct-writing oscillograph for monitoring model dynamics.

SECTION III TEST DESCRIPTION

3.1 PROCEDURE

For a given fin orientation, data were obtained while holding Mach number constant and varying the angle of attack between -3 and 19 deg. The model was tested at Mach numbers from 0.6 to 1.1 at simulated pressure altitudes of 15,000 ft, Mach number 1.2 at 25,000 ft and Mach number 1.4 at 28,400 ft. The corresponding Reynolds numbers are presented in Fig. 4.

3.2 DATA REDUCTION

The force and moments were corrected for weight tares and reduced to coefficient form in the nonrolling body axis system. Pitching and yawing moments were determined about the M-117 Bomb center of gravity which was located at a common model station 28.11 in. aft of the nose. All force and moment coefficients are based on the model maximum diameter and cross-sectional area.

3.3 PRECISION OF MEASUREMENTS

An estimate of the accuracy of measurements is presented in the following table:

| M_∞ | $\pm\alpha$, deg | $\pm C_m$ | $\pm C_N$ | $\pm C_Y$ | $\pm C_n$ | $\pm C_A$ | $\pm C_\ell$ | $\pm M_\infty$ |
|------------|-------------------|-----------|-----------|-----------|-----------|-----------|--------------|----------------|
| 0.6 | 0.1 | 0.053 | 0.050 | 0.042 | 0.041 | 0.008 | 0.0063 | 0.005 |
| 1.4 | 0.1 | 0.017 | 0.016 | 0.014 | 0.013 | 0.003 | 0.0020 | 0.016 |

SECTION IV

RESULTS AND DISCUSSION

The primary purpose of this investigation was to determine the static longitudinal stability characteristics of various tail fin configurations attached to the M-117 Bomb. In addition, the effects of fin orientation on the static longitudinal stability were investigated for the MAU-103A/B and M131A1 configurations.

4.1 STATIC STABILITY (ZERO-DEGREE FIN ORIENTATION)

The normal-force and pitching-moment coefficients as a function of angle of attack for each configuration are presented in Figs. 5 and 6. The stability data are summarized in Figs. 7 and 8. The static longitudinal stability characteristics of the M-117 Bomb can be interpreted from the slope of the pitching-moment versus normal-force coefficient plots presented in Fig. 7. As shown in Fig. 7, the M-117 Bomb was statically stable with all three fin configurations at zero-degree fin orientation throughout the angle-of-attack and Mach number ranges of the test. The stability of the M-117 Bomb increased slightly at angles of attack above 4 deg for all three fin configurations. As shown in Fig. 8, all of the configurations tested are stable ($-x_{np}$) at zero-degree angle of attack and zero-degree fin orientation for the Mach number range of the test. The M131A1 and the M131A1 (modified shape) configurations exhibited essentially the same static stability margin for all test Mach numbers. The MAU-103A/B configuration exhibited the least margin of stability and had a minimum static stability margin of 0.46 calibers at Mach number 1.0.

4.2 FIN ORIENTATION

4.2.1 Static Stability

Normal-force and pitching-moment coefficients of the MAU-103A/B and the M131A1 configurations for various fin orientations are presented

as a function of angle of attack in Figs. 9 and 10. For angles of attack greater than zero, the magnitude of the normal-force and pitching-moment coefficients decreases as the fin orientation angle is increased up to -45° or compliments of 45° . As shown in Fig. 11, this decrease in normal-force and pitching-moment coefficient resulted in slightly less static stability of the M-117 Bomb at the higher angles of attack.

Neutral-point location of the MAU-103A/B and of the M131A1 configurations versus Mach number for various tail fin orientations is presented in Fig. 12. As shown in Fig. 12, fin orientation had little effect on the static margin of stability of the MAU-103A/B and the M131A1 configurations at zero-degree angle of attack.

4.2.2 Induced Forces and Moments

Side forces and yawing and rolling moments induced on a symmetrical vehicle are produced by the combination of angle of attack and fin orientation and became significant only at the higher angles of attack. The data show that the induced force and moment coefficients increased to a maximum magnitude as the fin orientation angle was increased to -22.5° or any compliment of 22.5° . The magnitude of the induced force and moment coefficients decreased from the maximum magnitude at -22.5° to essentially the magnitude of the zero-degree fin orientation at -45° . The induced side forces and yawing and rolling moments are the results of interaction between the fins and the body at high angles of attack. In addition to the induced forces and moments from fin orientation there could be forces and moments produced by small misalignment of the tail fin assembly.

The variation of the induced side-force coefficient with angle of attack, fin roll orientation, and Mach number for the MAU-103A/B and the M131A1 configurations is shown in Fig. 13. The induced side forces for both configurations are much larger in magnitude at the subsonic Mach numbers than at the supersonic Mach numbers. The induced side-force coefficients for the MAU-103A/B are larger than those for the M131A1 configuration at corresponding angles of attack.

The effect of fin orientation on induced yawing-moment coefficient as a function of angle of attack is shown in Fig. 14 for various Mach numbers. The magnitude of the induced yawing-moment coefficient for the M131A1 configuration for a fin orientation angle of -22.5° is generally less than the magnitude of the MAU-103A/B configuration with a fin orientation angle of -11.25° .

The variation of the induced rolling-moment coefficient with angle of attack, fin orientation, and Mach number is shown in Fig. 15. At subsonic Mach numbers there was little or no induced rolling-moment coefficient with the M131A1 configuration and only at the supersonic Mach numbers and extremely high angles of attack did the M131A1 configuration have any significant induced rolling-moment coefficient. The induced rolling-moment coefficient of the MAU-103A/B configuration at high angles of attack decreased from a large positive value to a large negative value as Mach number increased.

4.3 AXIAL FORCE

The variation of axial-force coefficient with Mach number for the three configurations investigated at zero angle of attack is presented in Fig. 16. As would be expected, the thicker, blunt trailing-edge fins (M131A1 modified shape) had a larger axial-force coefficient at all test conditions. The increase in axial-force coefficient of the M131A1 (modified shape) configuration over that of the M131A1 configuration was about three percent.

SECTION V CONCLUDING REMARKS

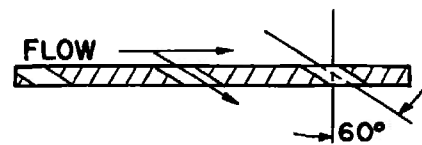
Aerodynamic force and moment data were obtained to determine the static stability characteristics of the M-117 Bomb for various tail fin configurations at Mach numbers from 0.60 to 1.40. The results of the investigation are summarized below:

1. All configurations investigated are stable for the angle-of-attack and Mach number range of the test.
2. The MAU-103A/B configuration exhibited the least margin of stability and had a minimum static stability margin of 0.46 calibers at Mach number 1.0.

REFERENCES

1. Lehner, Paul. "Static Stability Tests of the M-117 Bomb at Mach Numbers from 0.55 to 1.30 with Seven Tail Fin Configurations." AEDC-TR-68-103 (AD832710), May 1968.
2. Test Facilities Handbook (6th Edition). "Propulsion Wind Tunnel Facility, Vol. 5." Arnold Engineering Development Center, November 1966.

**APPENDIX
ILLUSTRATIONS**



6% Open Area
Hole Diameter = 0.75 in.
Plate Thickness = 0.75 in.

**TYPICAL PERFORATED
WALL PATTERN**

Section A-A

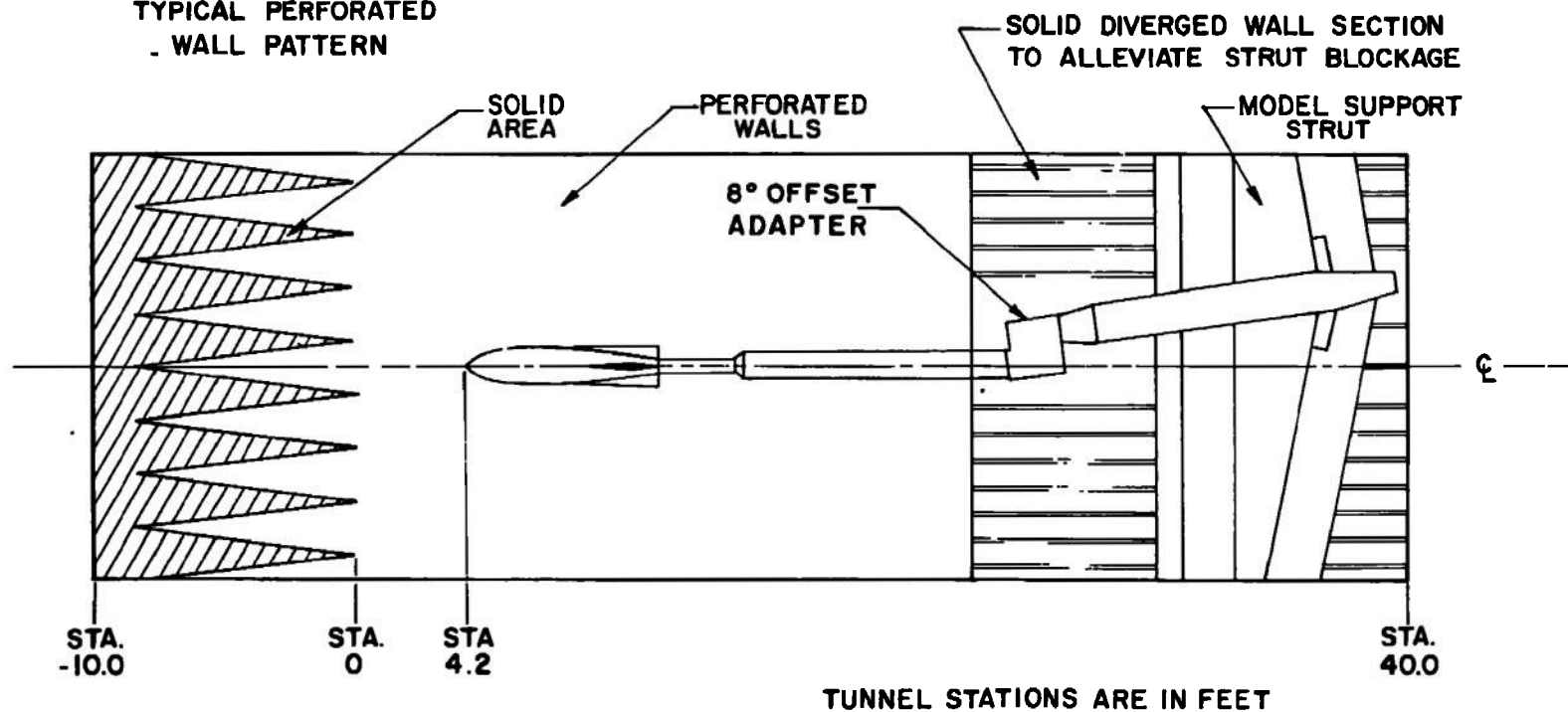
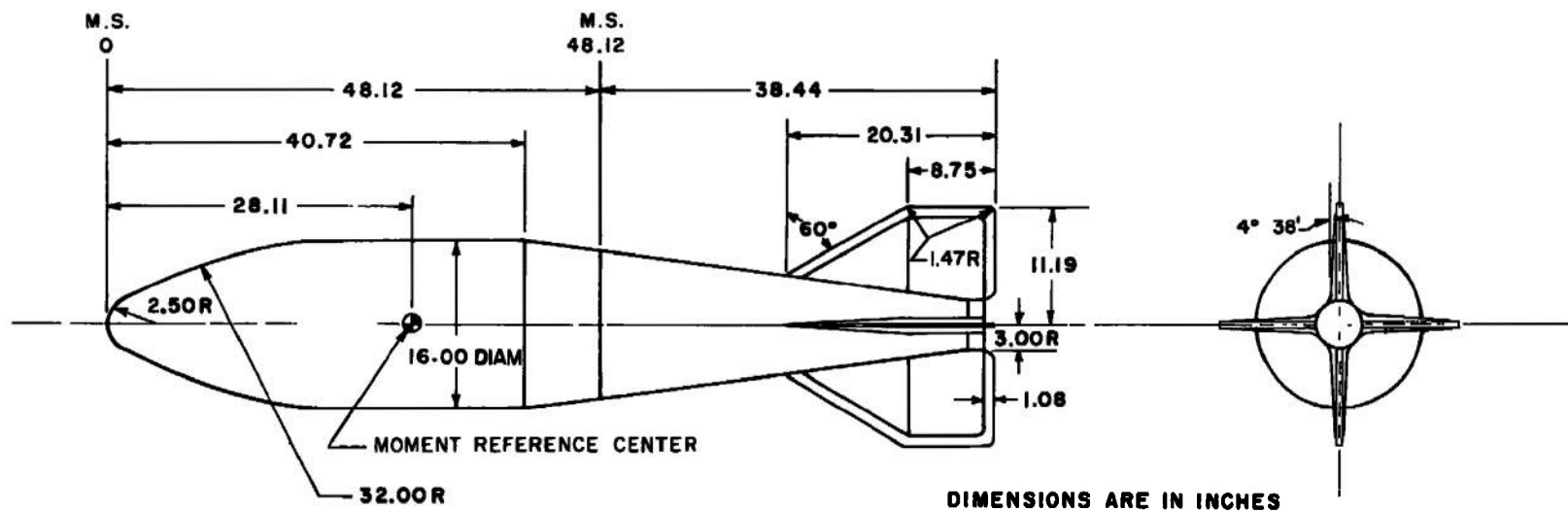
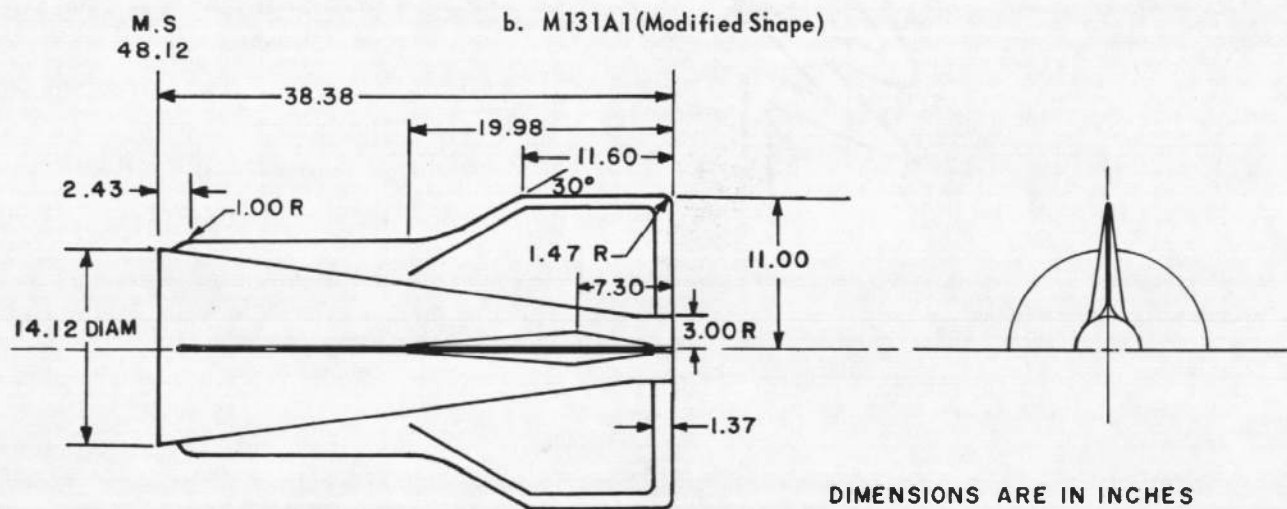
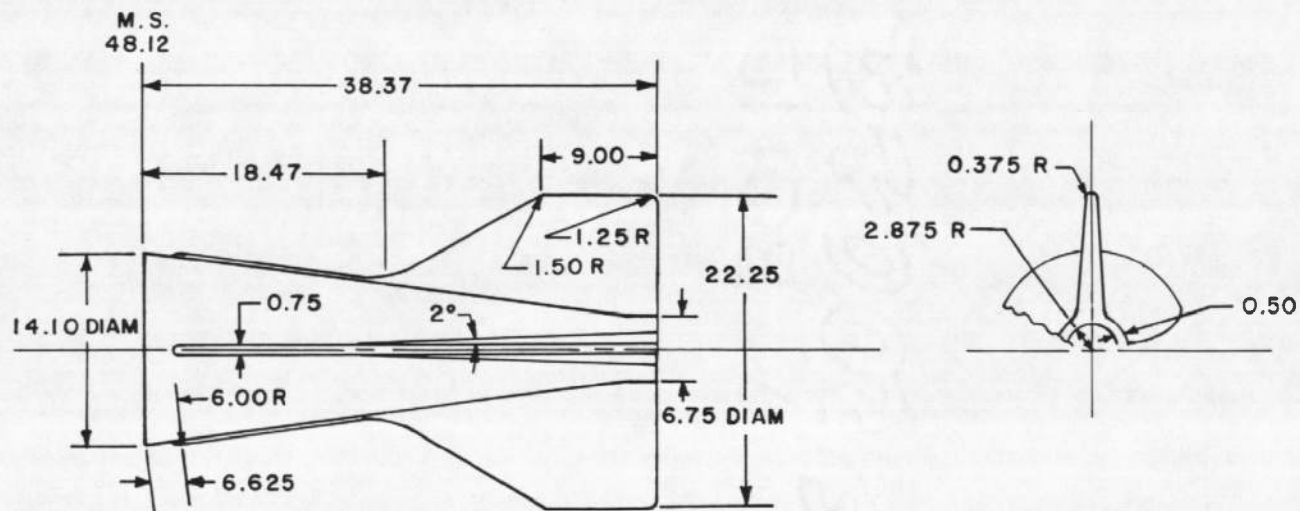


Fig. 1 Location of Model in Test Section



a. M-117 Bomb with M131A1 Fin

Fig. 2 Model Details



DIMENSIONS ARE IN INCHES

c. MAU-130A/B
Fig. 2 Concluded

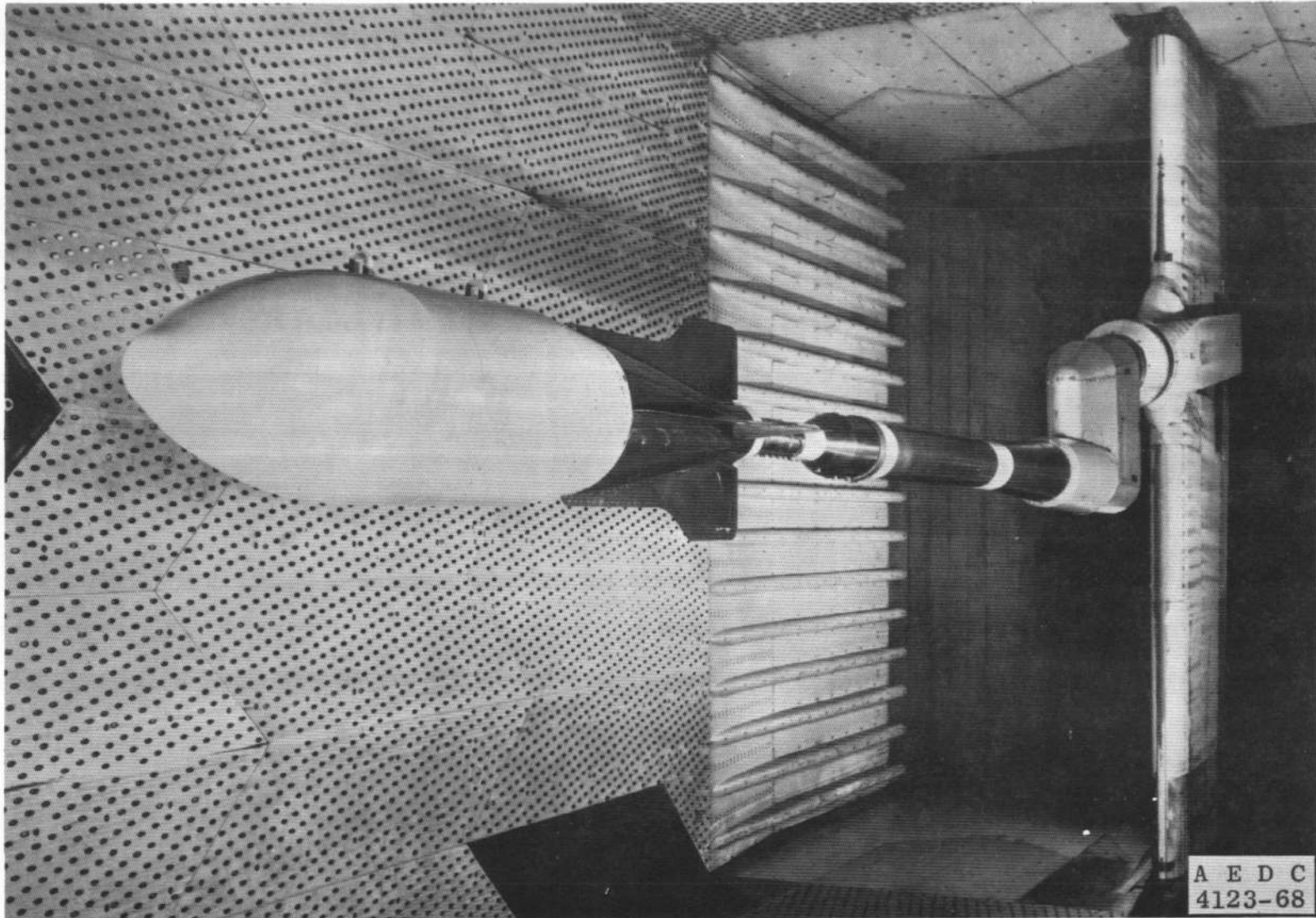


Fig. 3 Model Installed in the Test Section

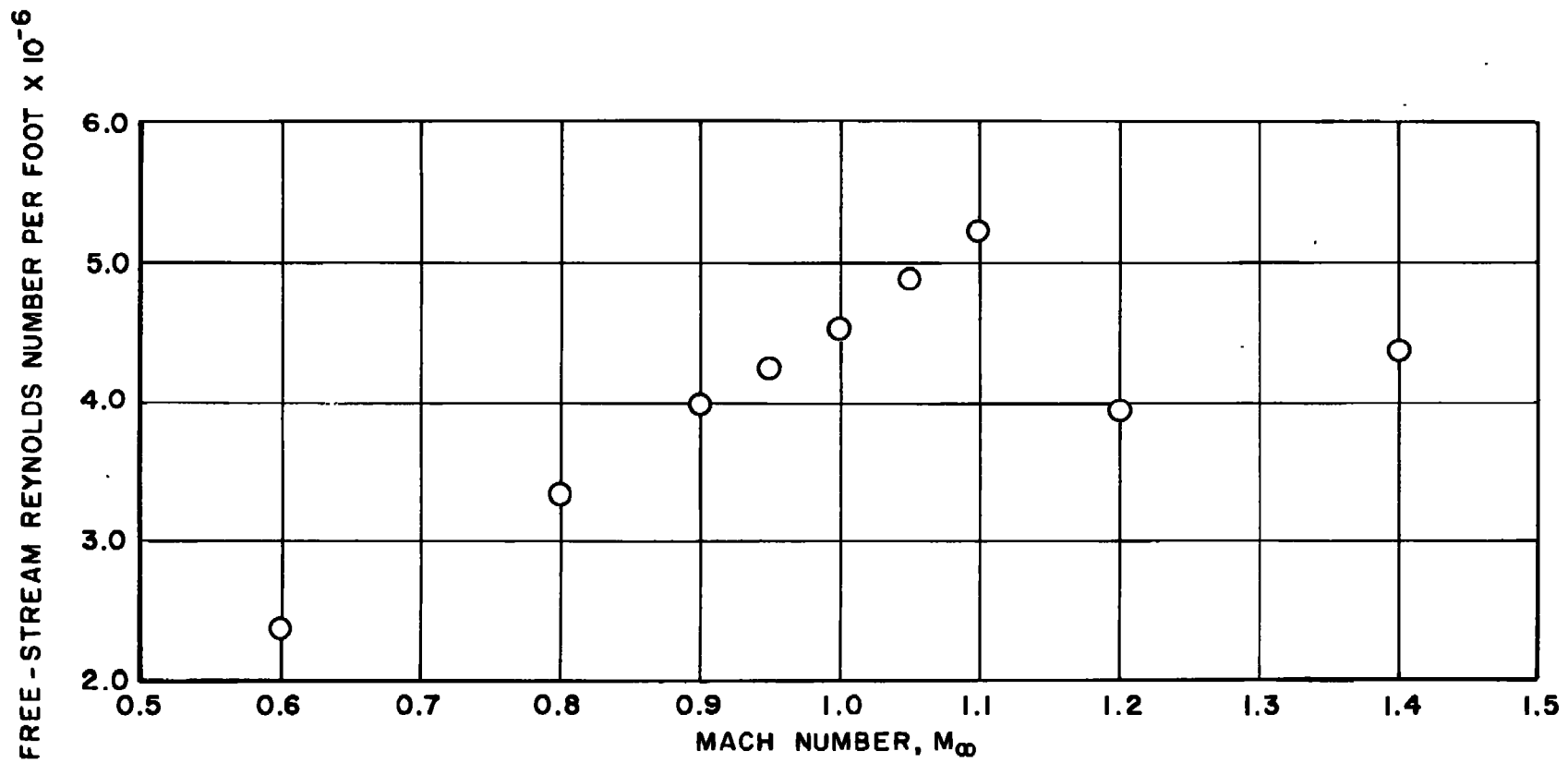
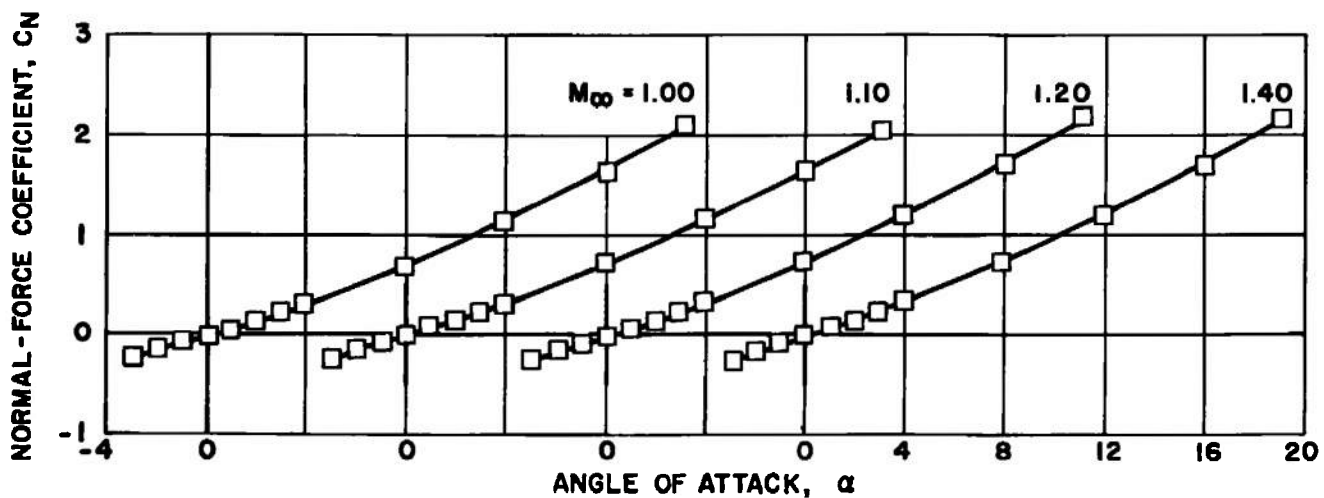
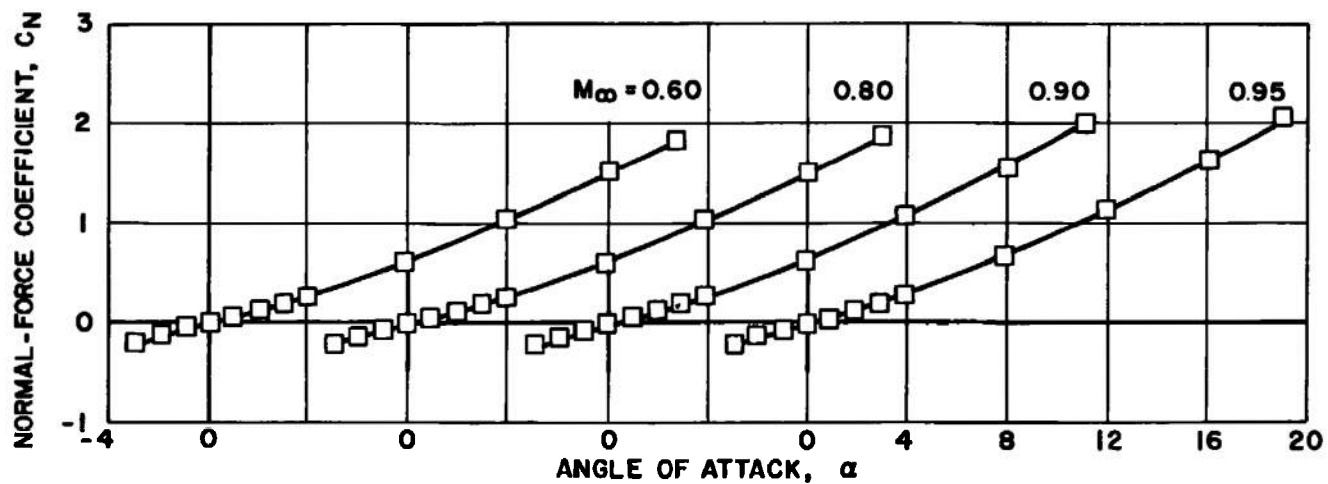
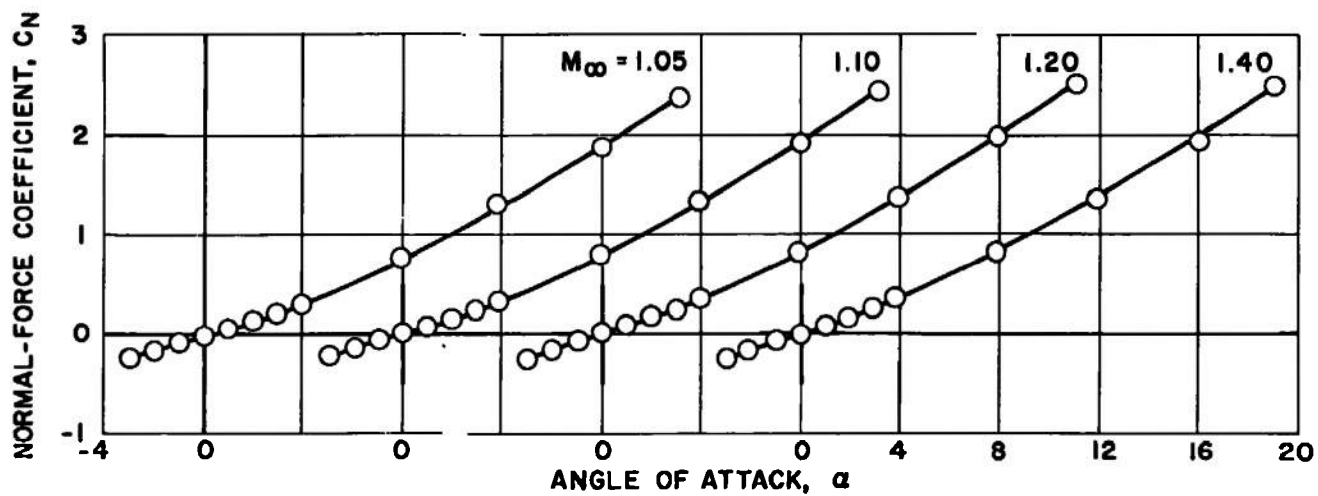
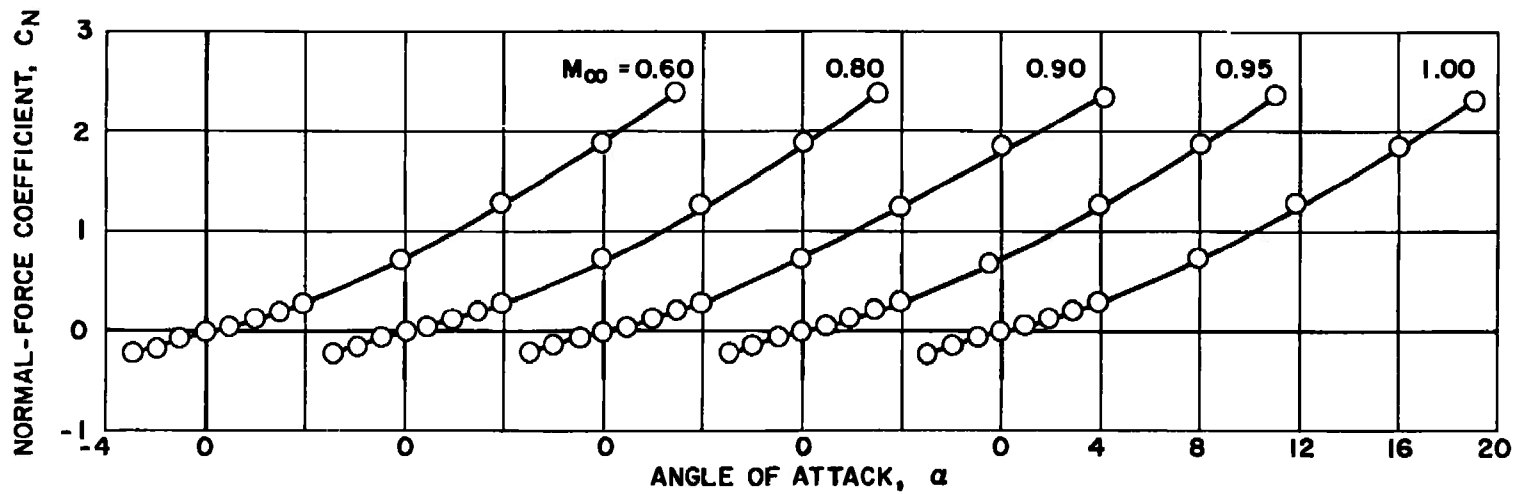


Fig. 4 Reynolds Number versus Mach Number

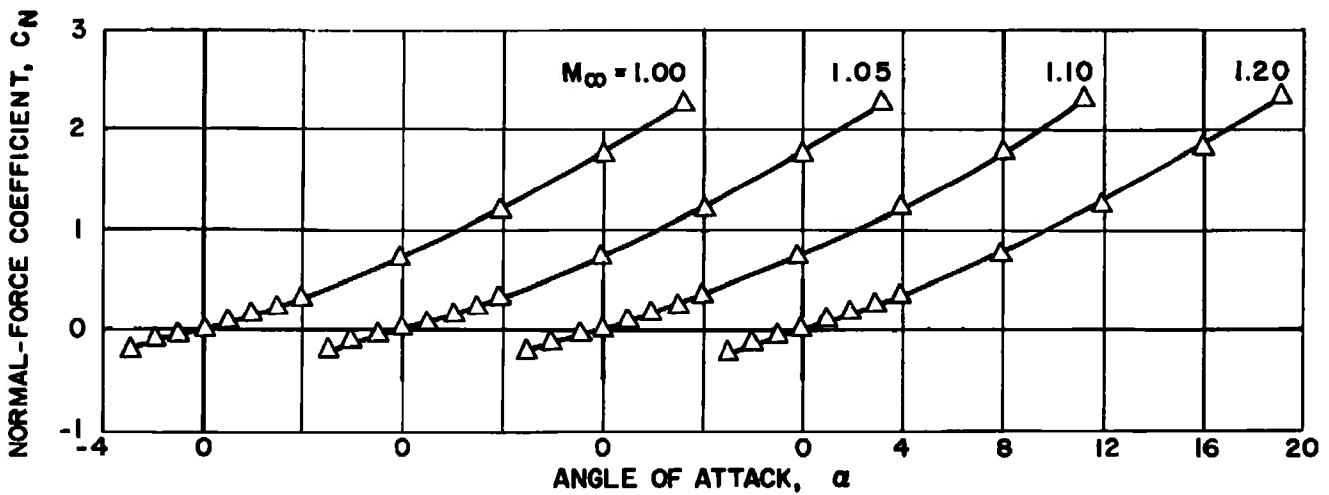
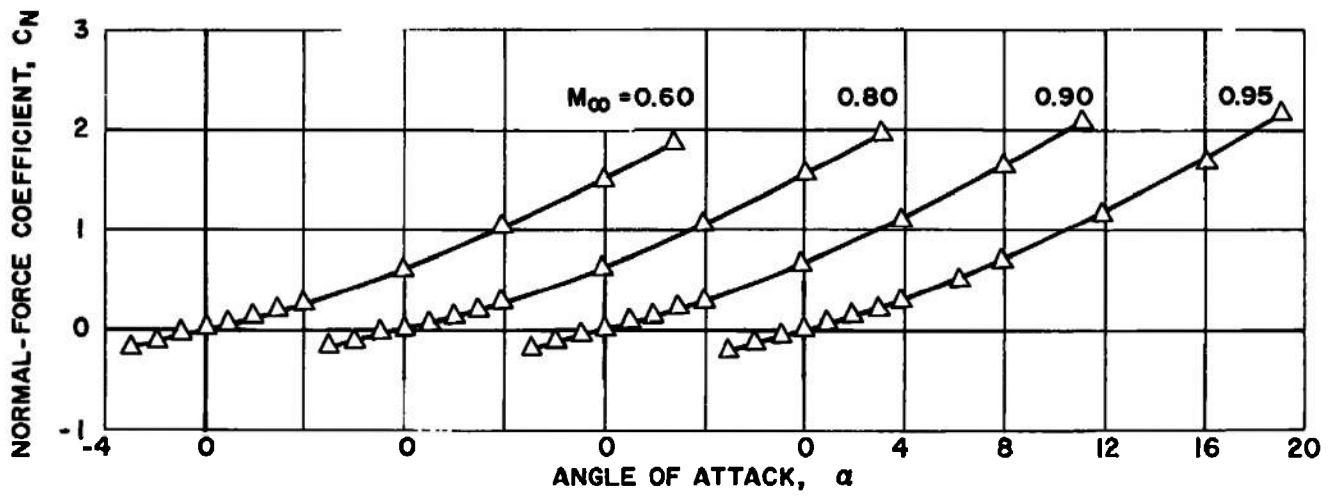


a. M131A1

Fig. 5 Variation of Normal-Force Coefficient with Angle of Attack, $\gamma = 0$ deg



b. MAU-103A/B
Fig. 5 Continued



c. M131A1 (Modified Shape)
Fig. 5 Concluded

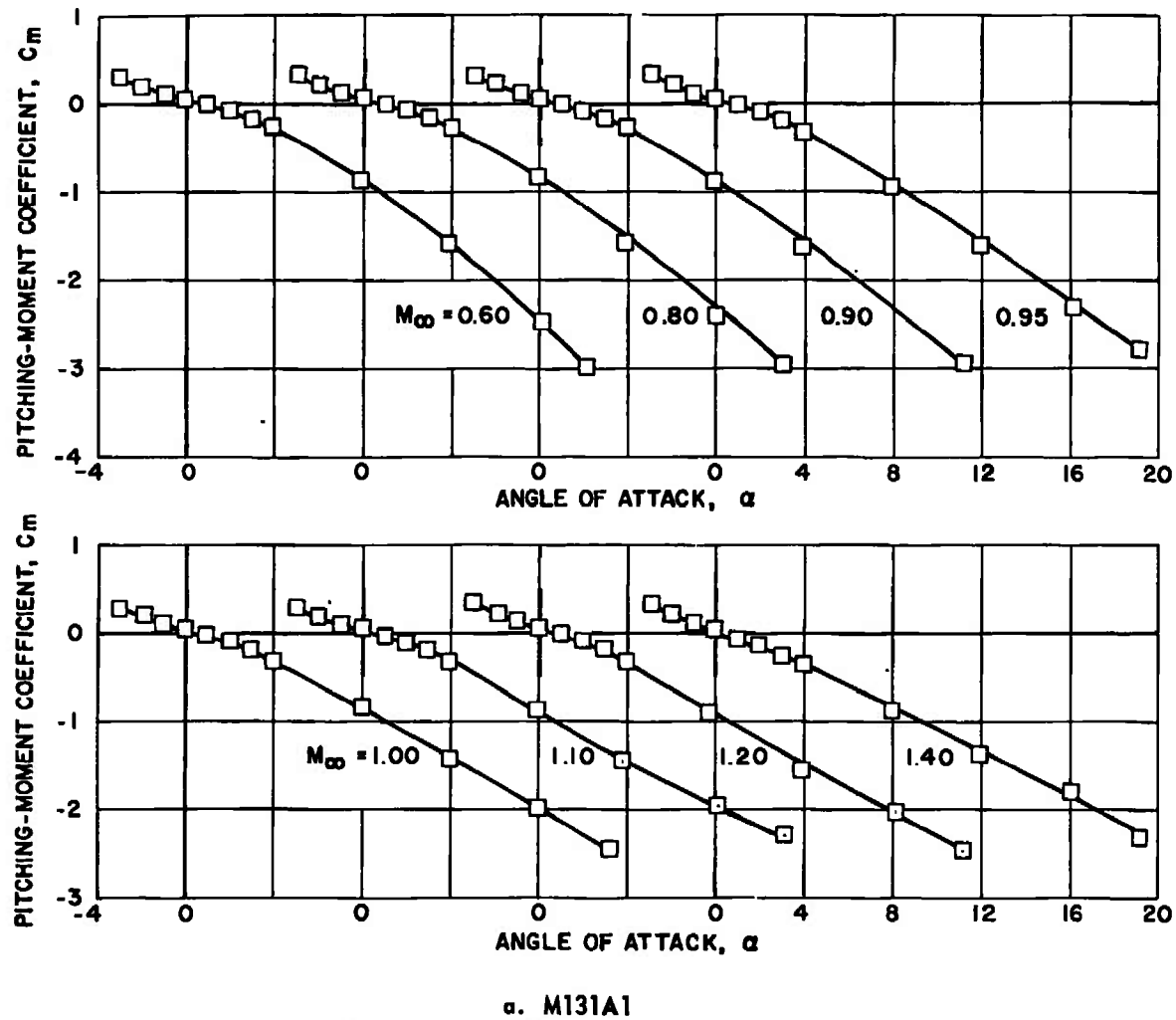
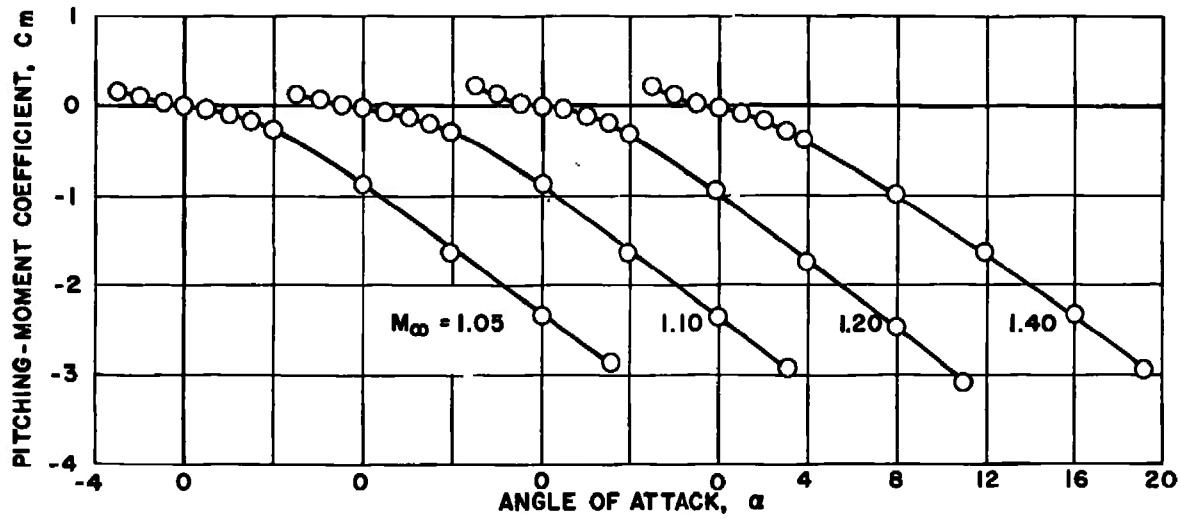
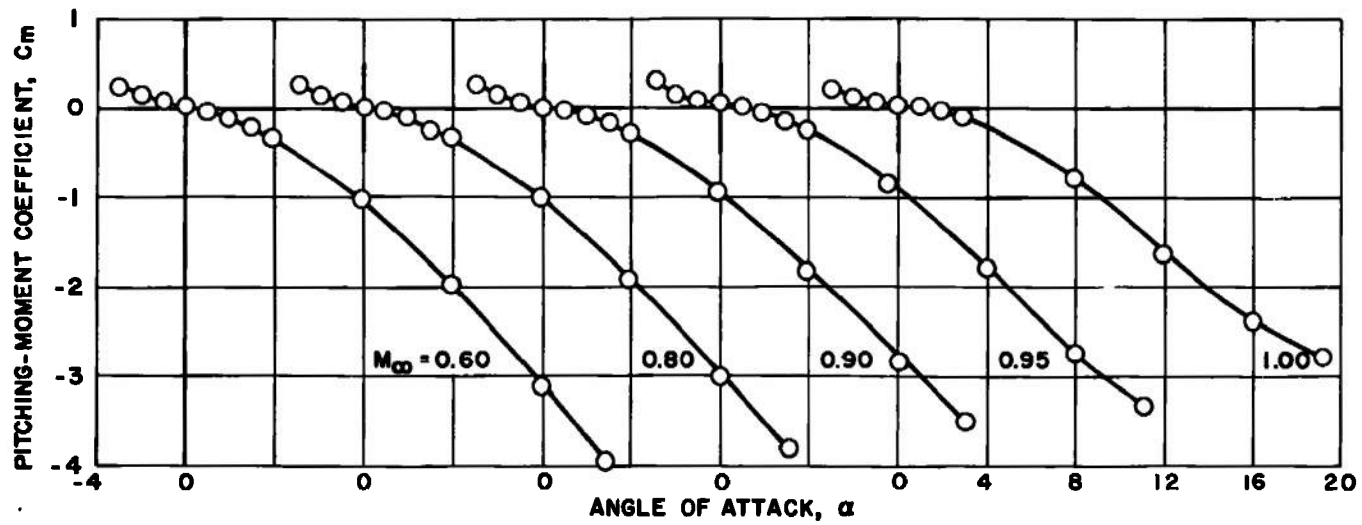
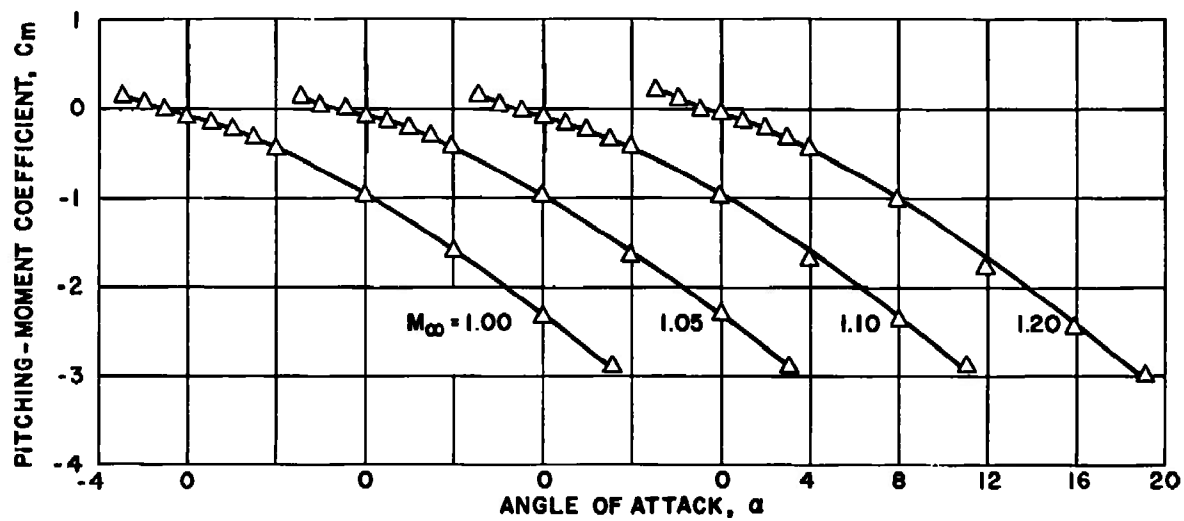
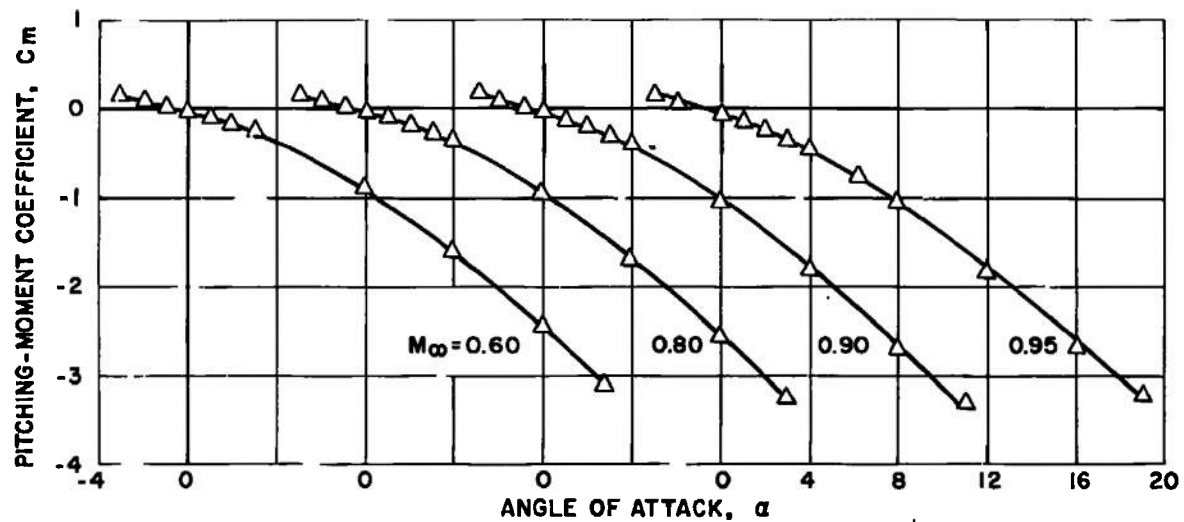


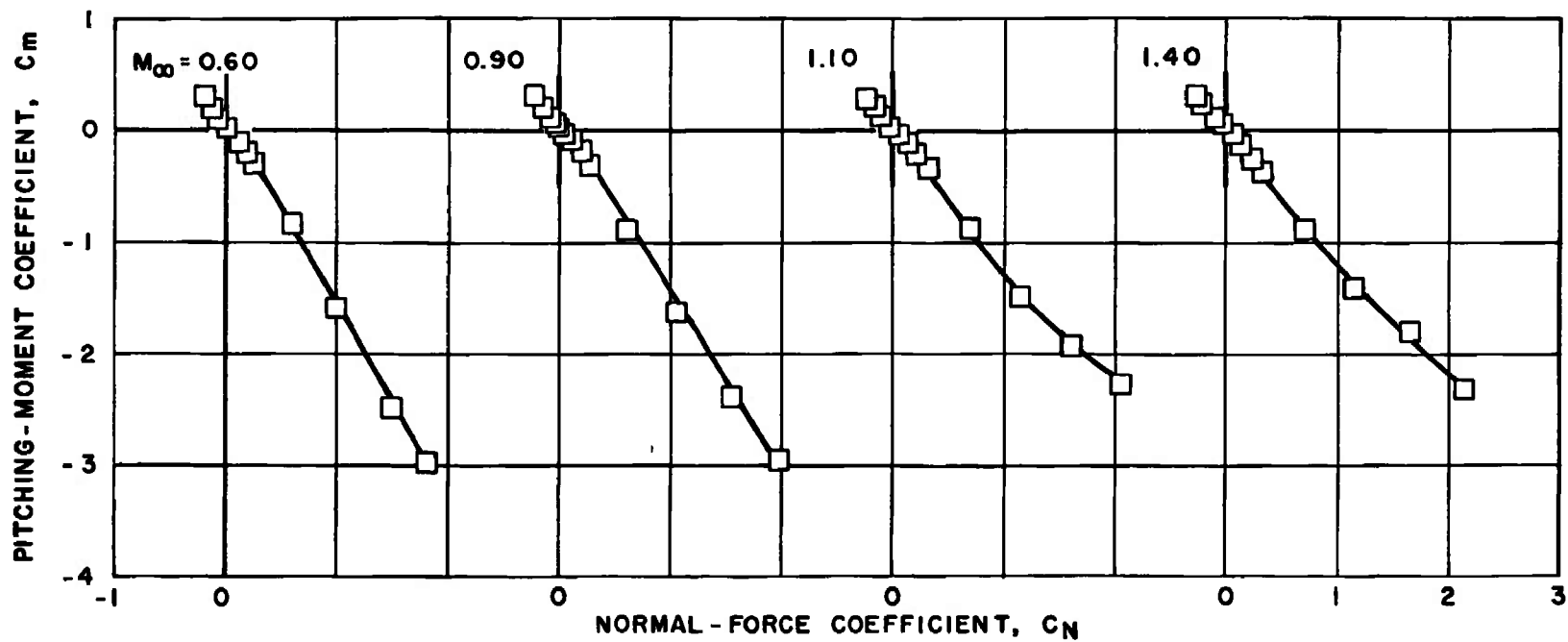
Fig. 6 Variation of Pitching-Moment Coefficient with Angle of Attack, $\gamma = 0^\circ$



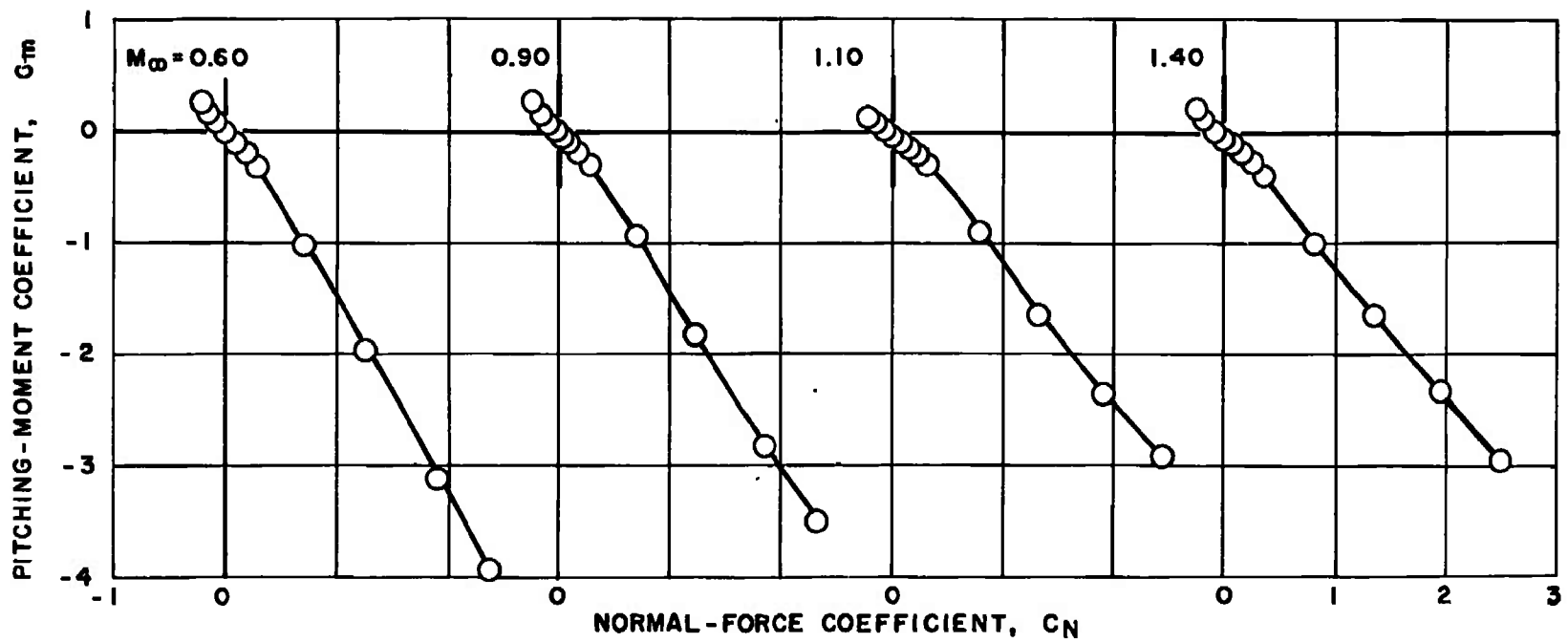
b. MAU-103A/B
Fig. 6 Continued



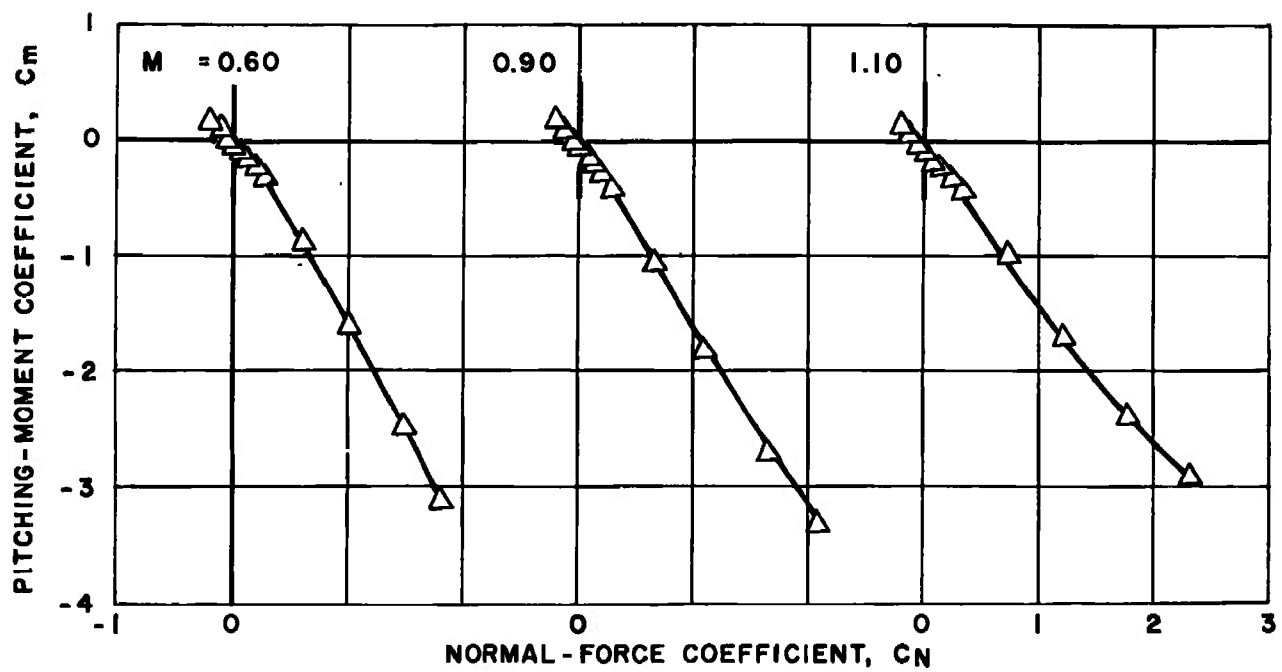
c. M131A1 (Modified Shape)
Fig. 6 Concluded



a. M131A1
 Fig. 7 Static Stability Characteristics, $\gamma = 0^\circ$



b. MAU-103A/B
Fig. 7 Continued



c. M131A1 (Modified Shape)
Fig. 7 Concluded

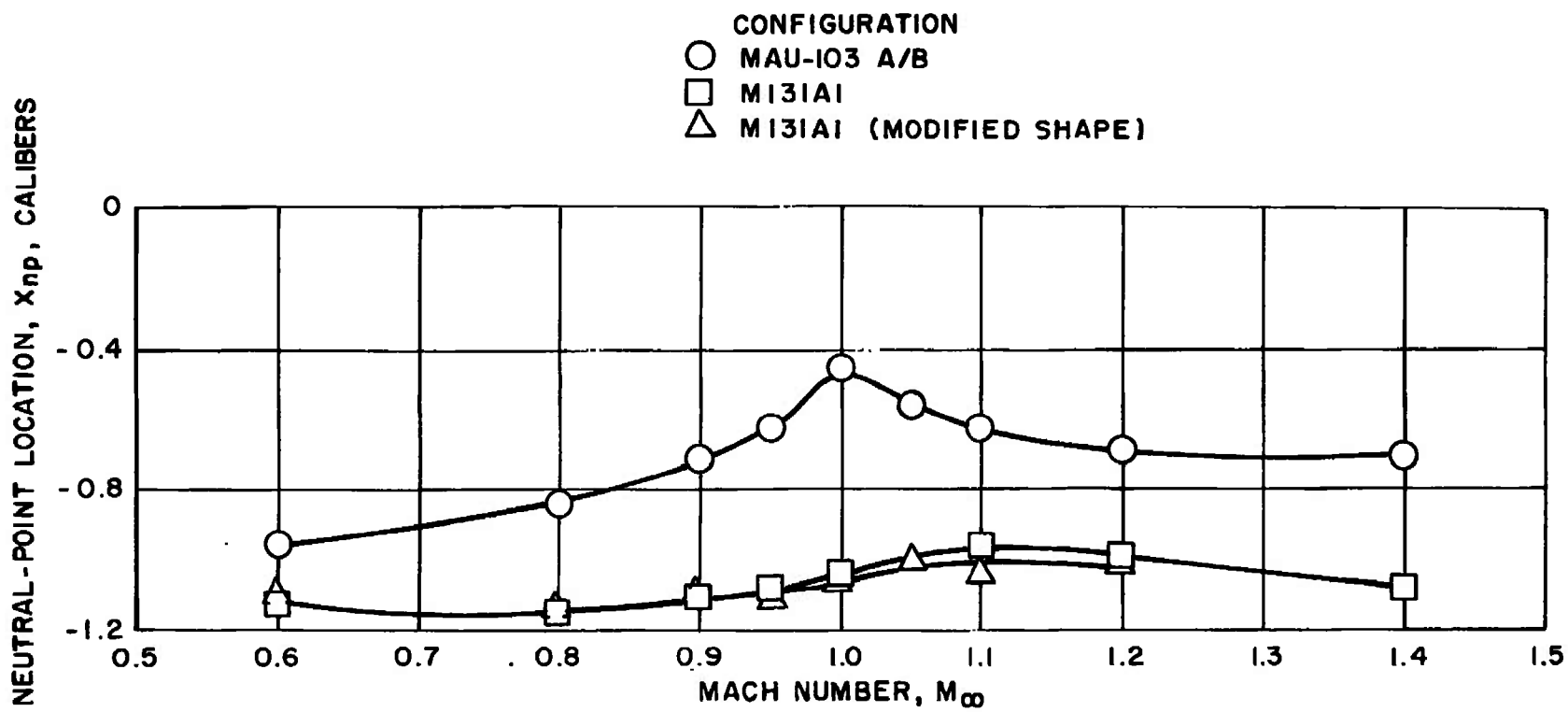
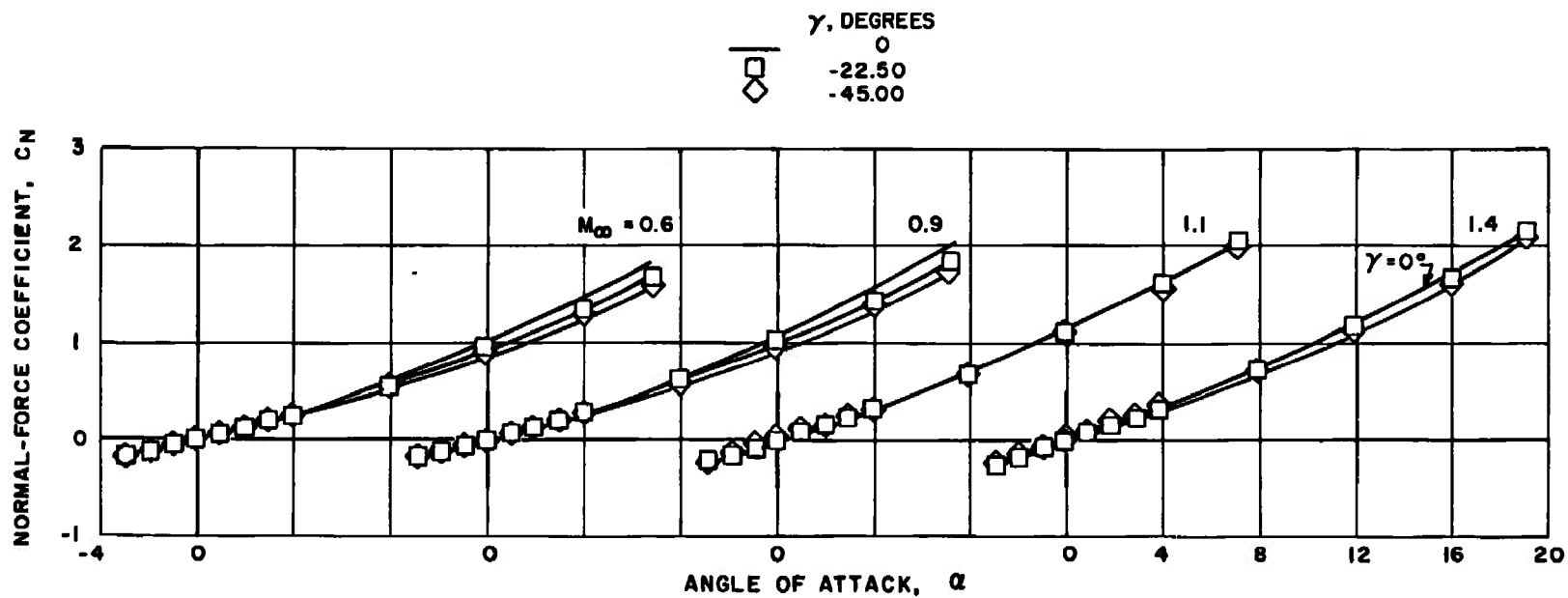
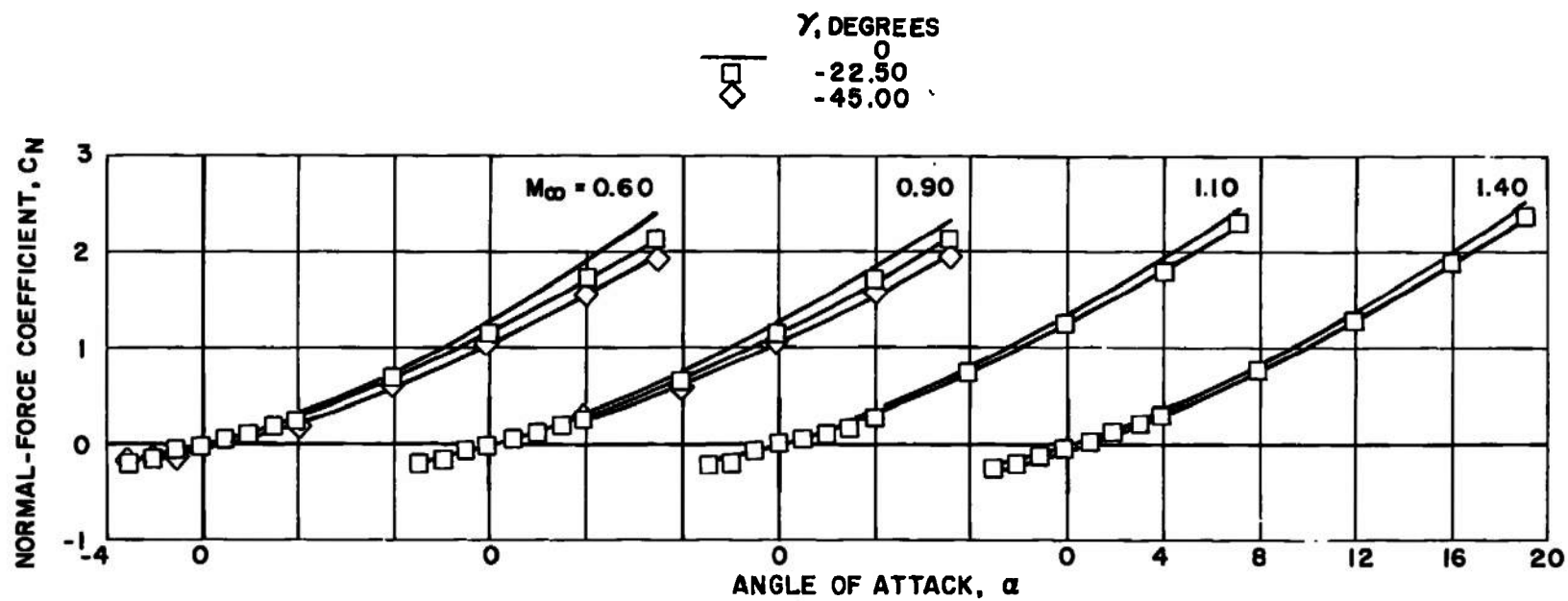


Fig. 8 Variation of Neutral-Point Location with Mach Number, $\gamma = 0$ deg

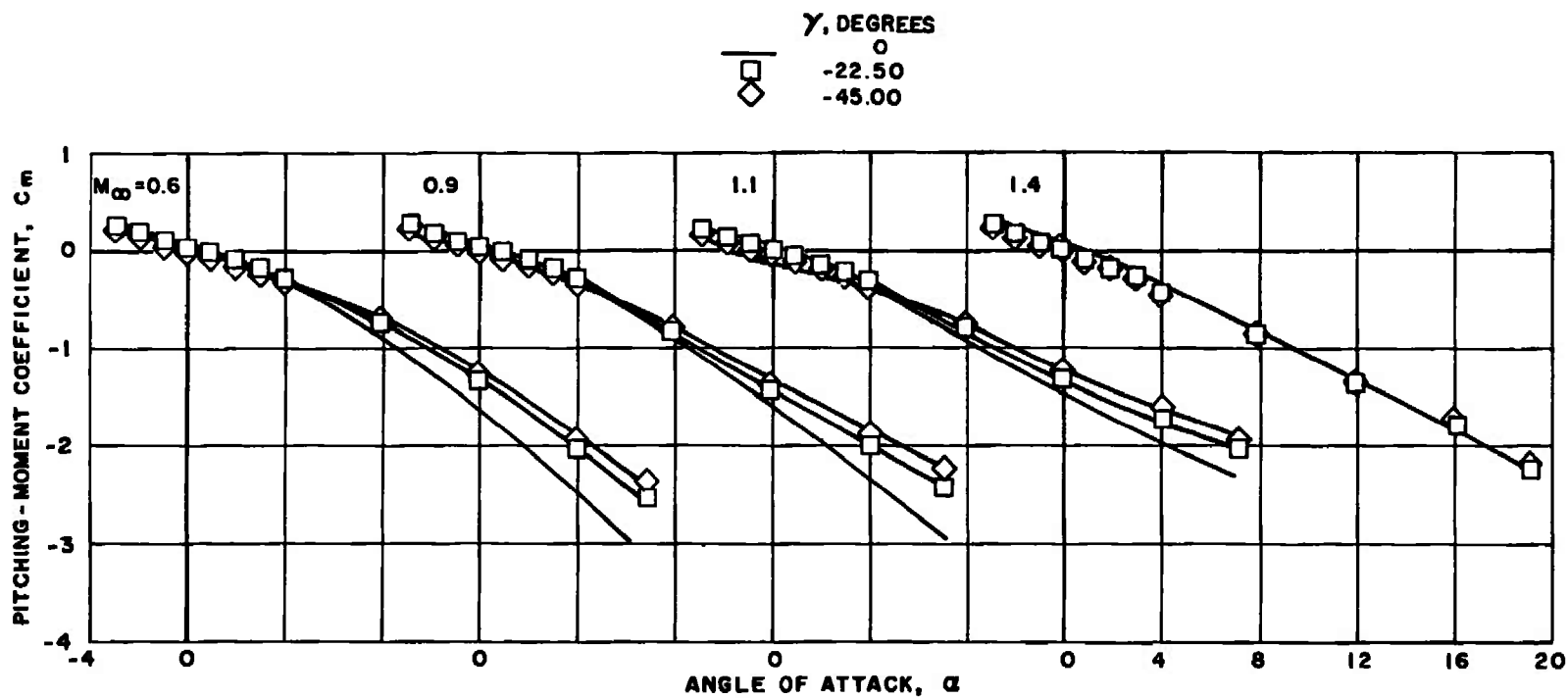


a. M131A1

Fig. 9 Effect of Fin Orientation on Normal-Force Coefficient

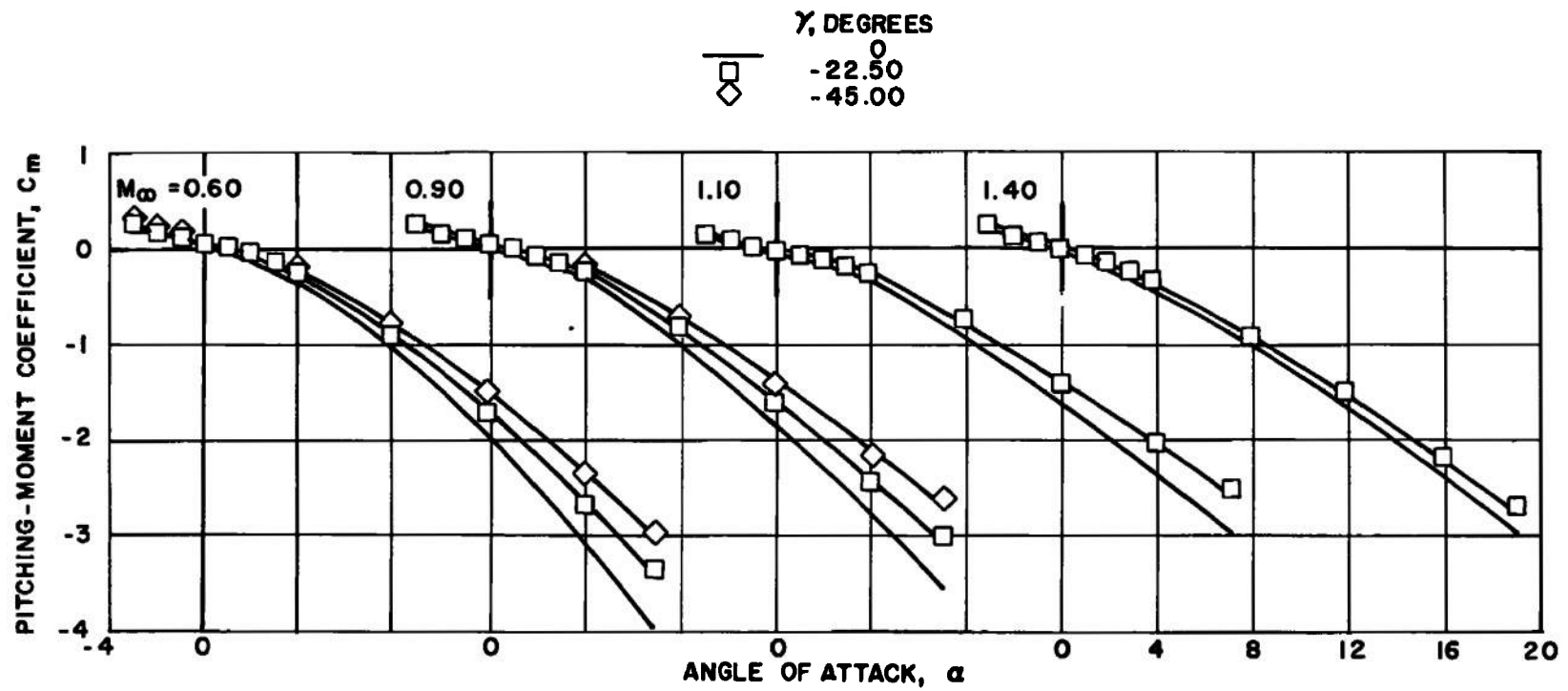


b. MAU-103A/B
Fig. 9 Continued

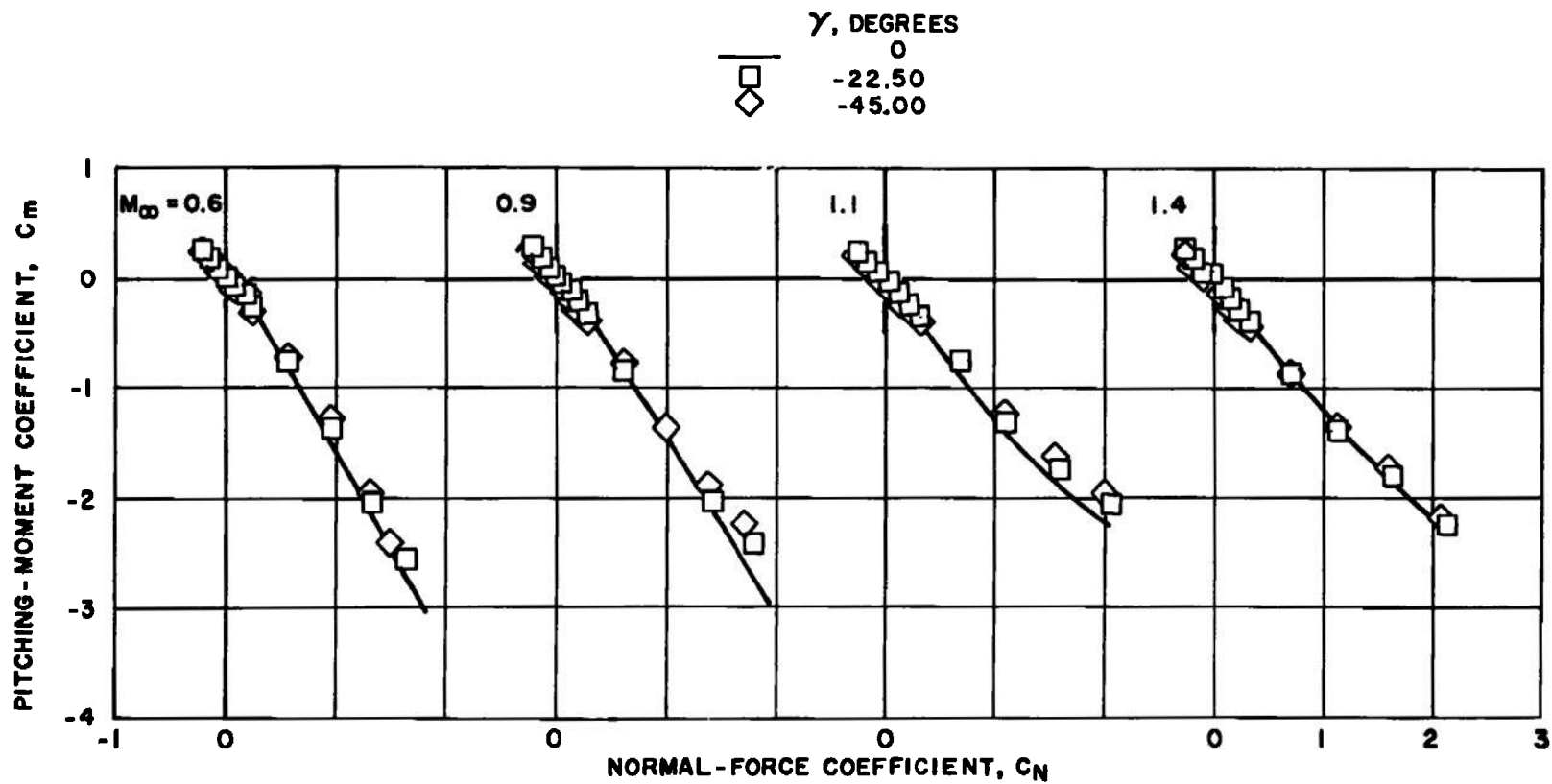


a. M131A1

Fig. 10 Effect of Fin Orientation on Pitching-Moment Coefficient

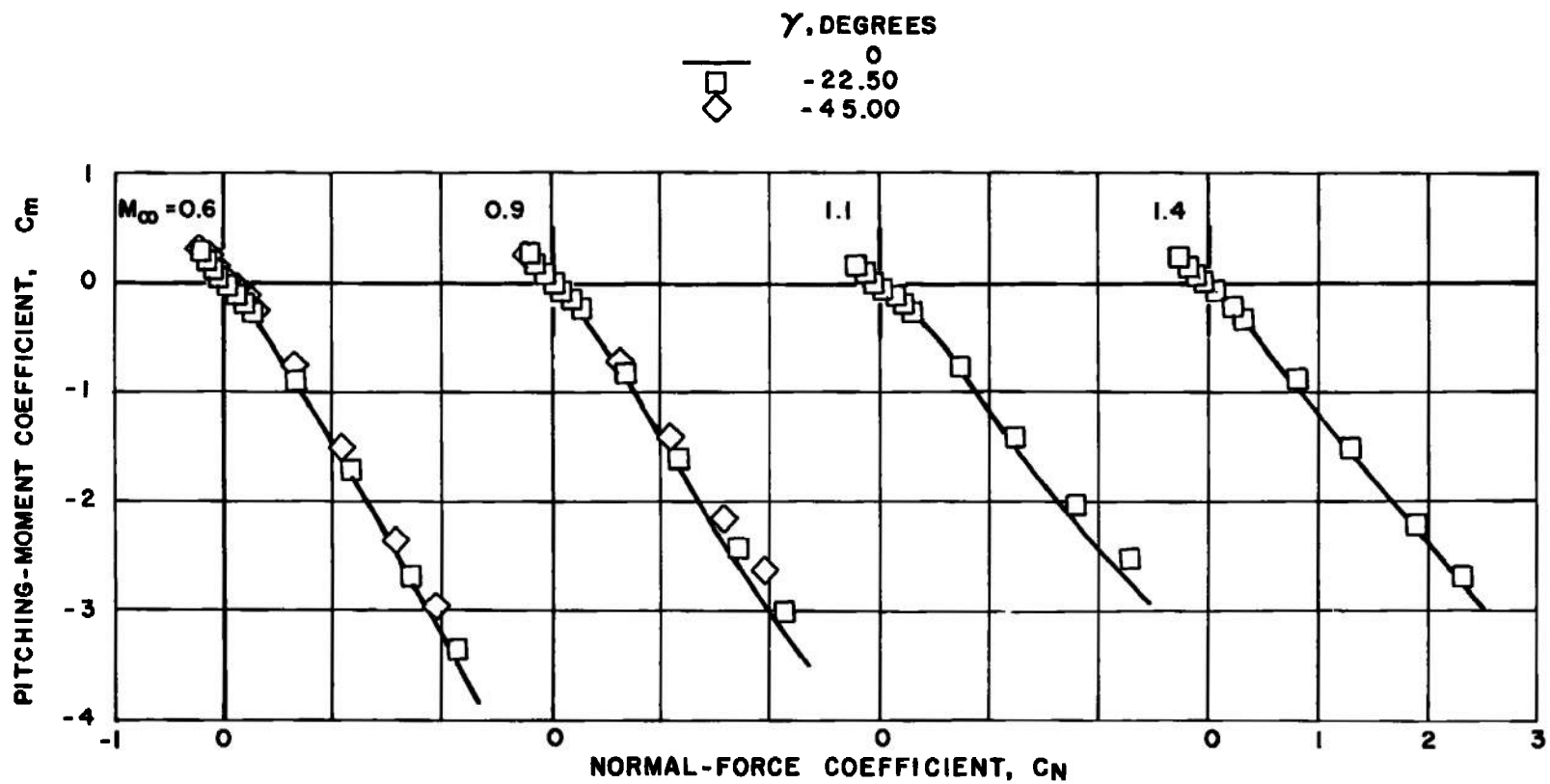


b. MAU-103A/B
Fig. 10 Concluded



a. M131A1

Fig. 11 Effect of Fin Orientation on the Static Stability Characteristics



b. MAU-103A/B
Fig. 11 Concluded

| | CONFIGURATION | γ , DEGREES |
|-----|---------------|--------------------|
| — | MAU-103 A/B | 0 |
| --- | M131A1 | 0 |
| □ | MAU-103 A/B | -11.25 |
| ○ | MAU-103 A/B | -22.50 |
| ● | M131A1 | -22.50 |
| △ | MAU-103 A/B | -33.75 |
| ◆ | M131A1 | -45.00 |

NEUTRAL-POINT LOCATION, x_{np} , CALIBERS

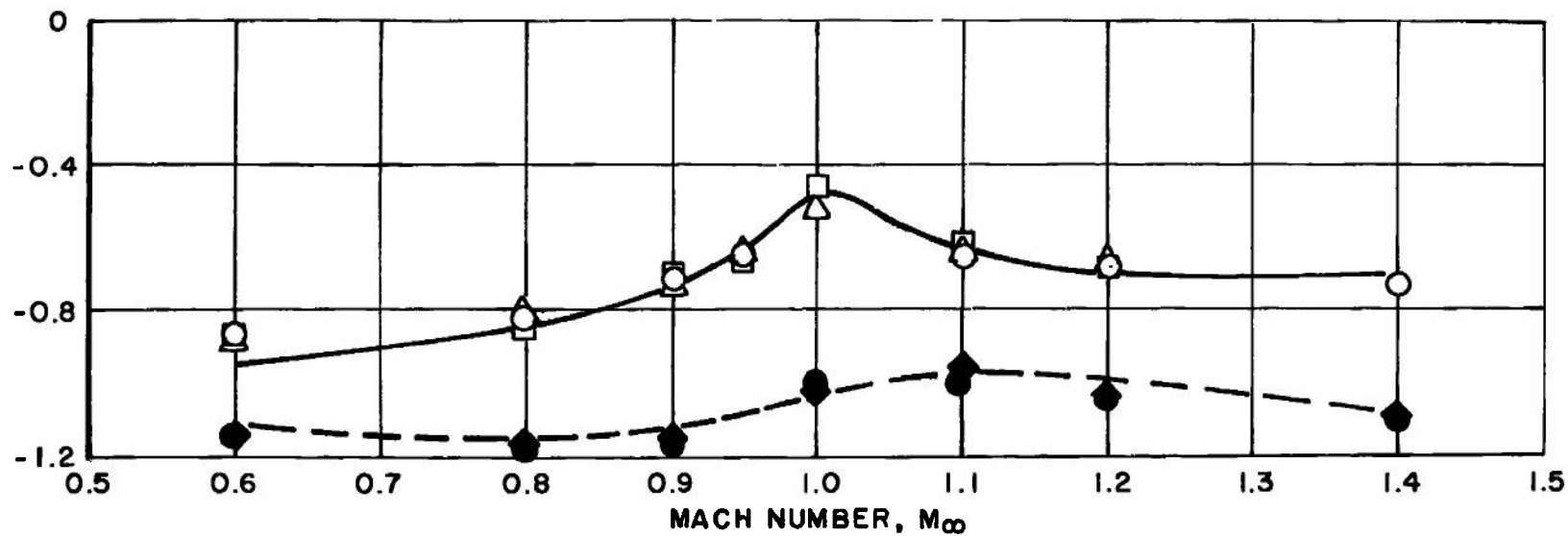


Fig. 12 Effect of Fin Orientation on Neutral-Point Location

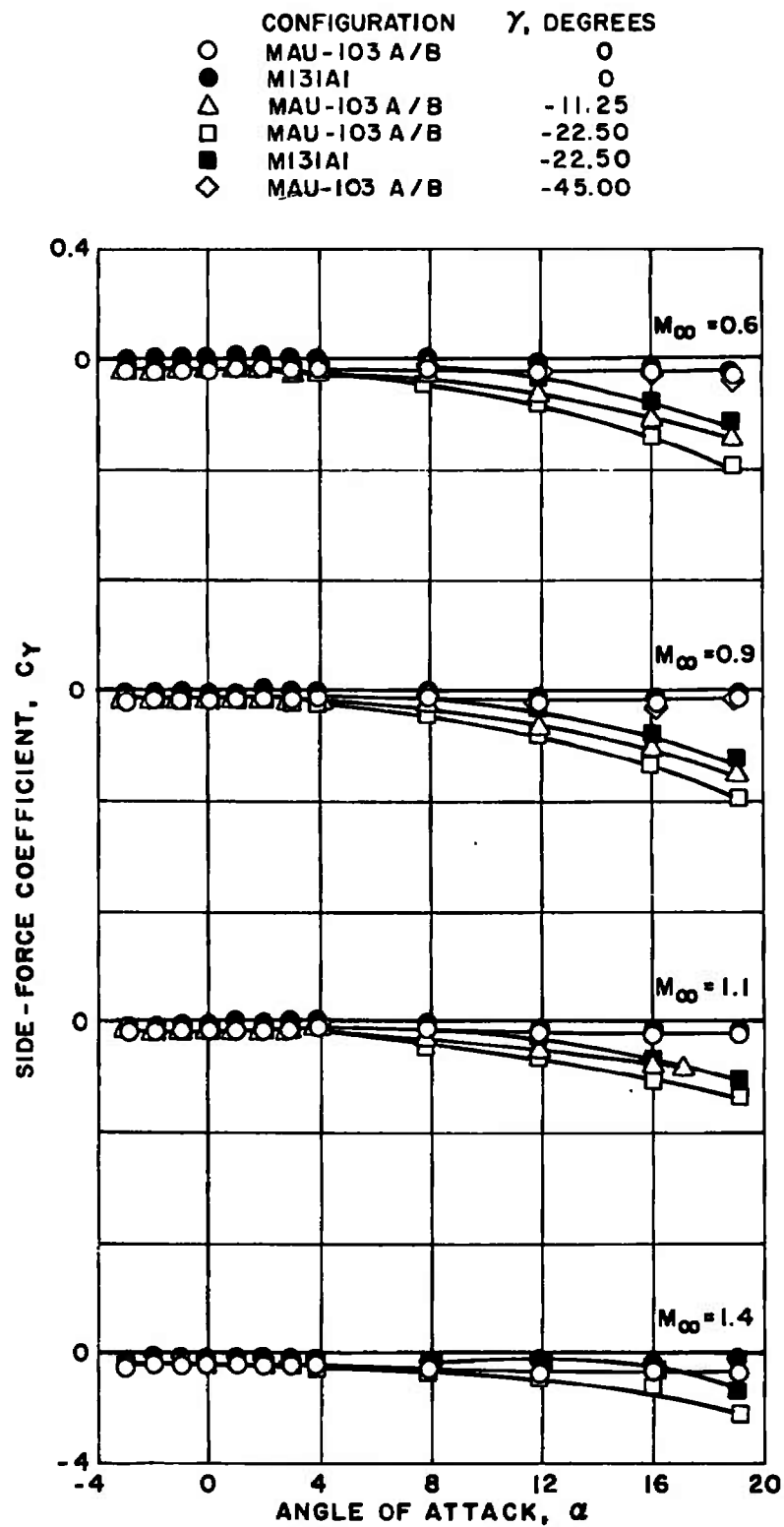


Fig. 13 Variation of Induced Side-Force Coefficient with Angle of Attack

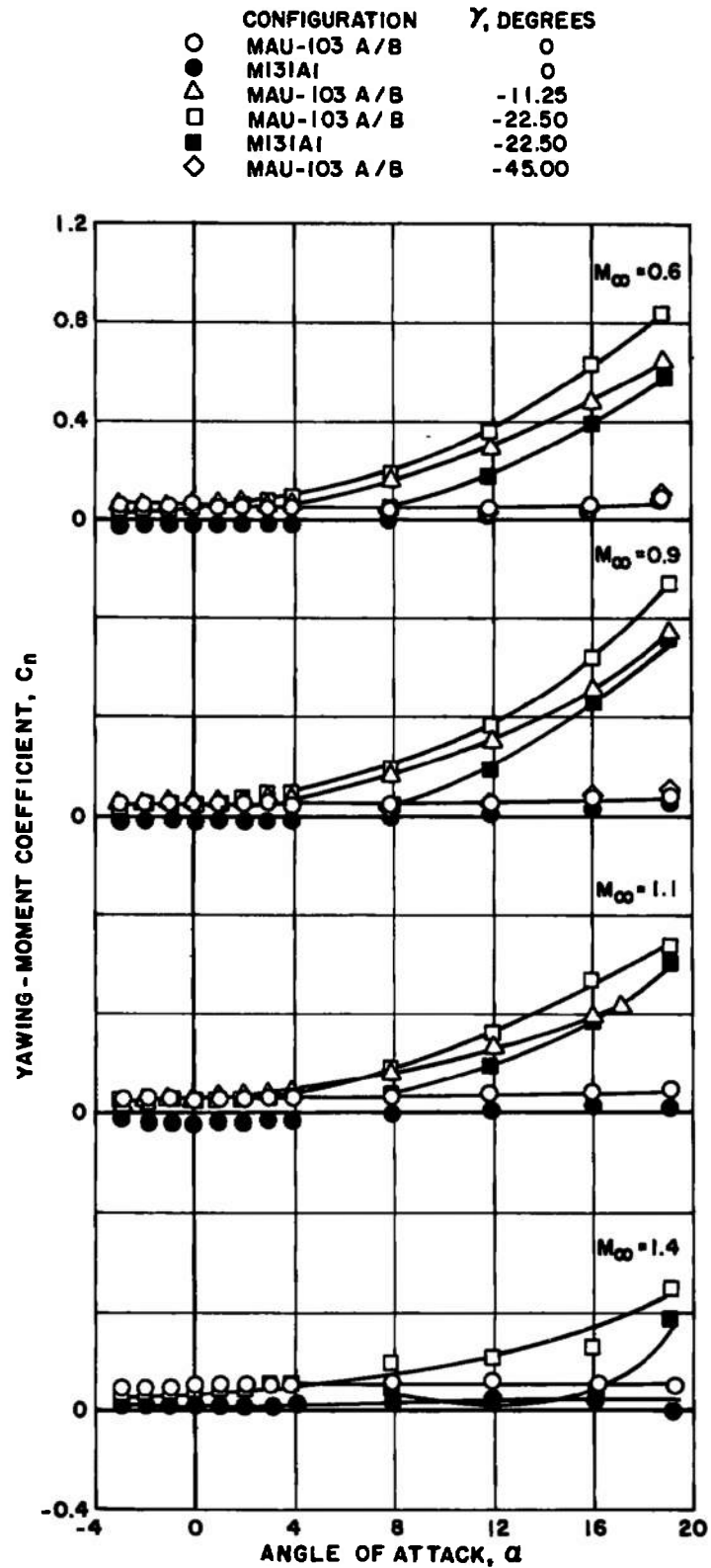


Fig. 14 Variation of Induced Yawing-Moment Coefficient with Angle of Attack

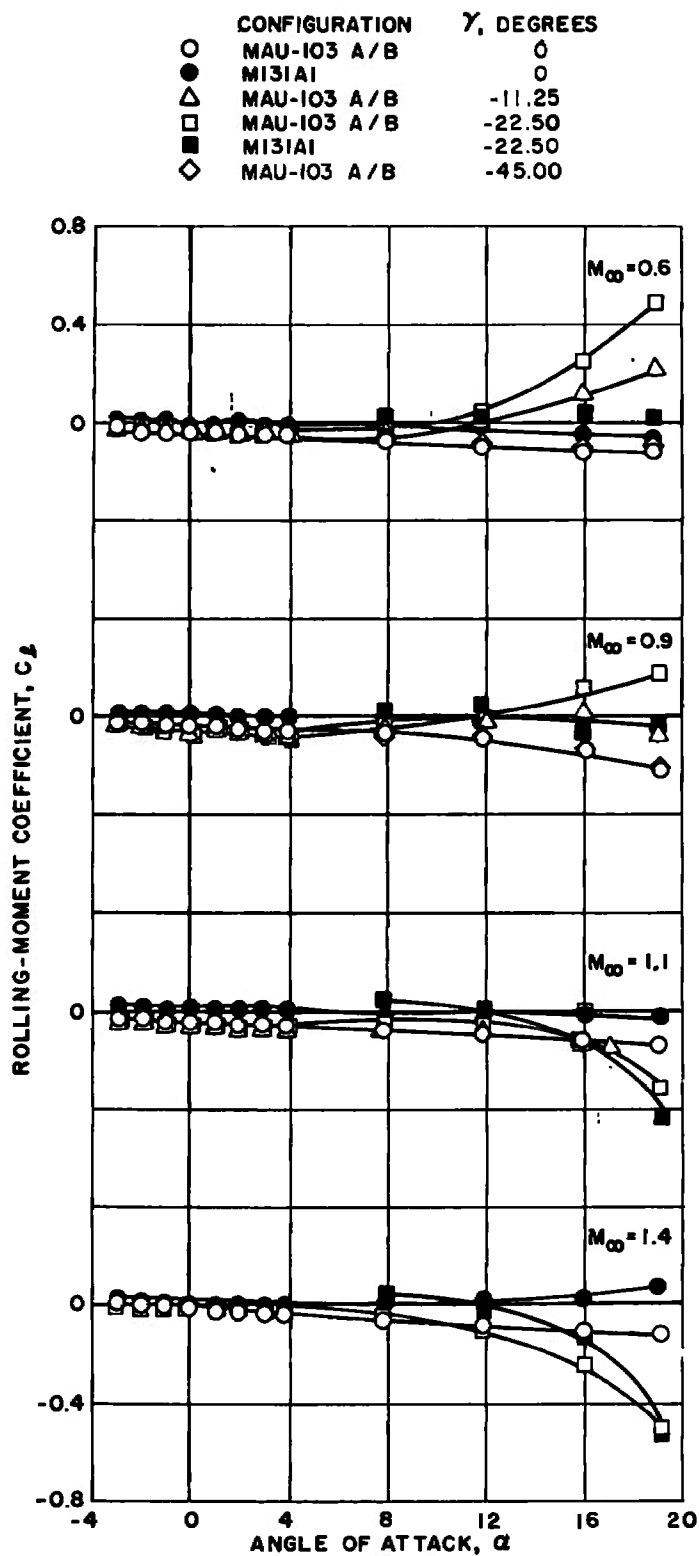


Fig. 15 Variation of Induced Rolling-Moment Coefficient with Angle of Attack

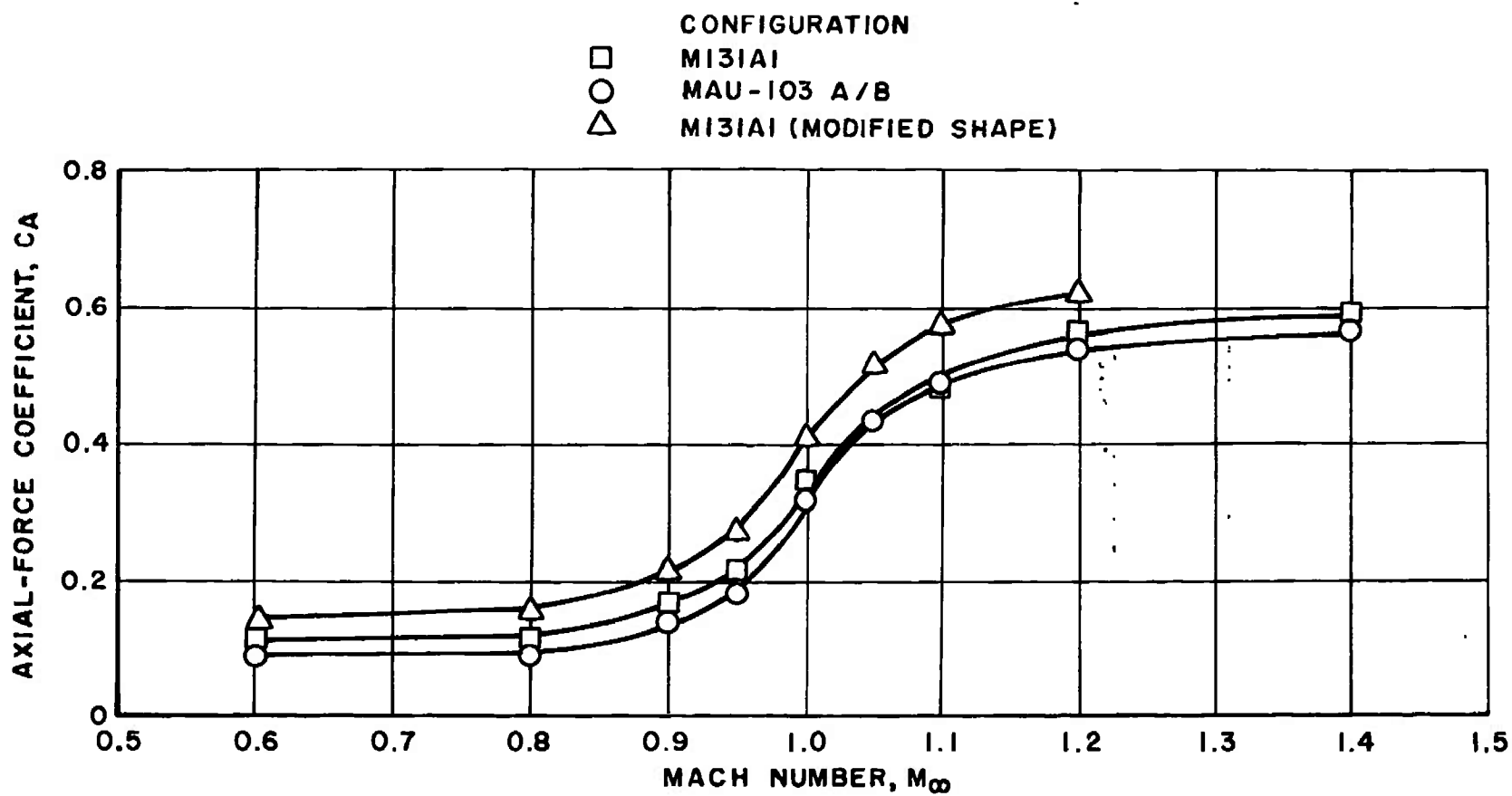


Fig. 16 Variation of Axial-Force Coefficient with Mach Number, $\alpha = 0$

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

| | | | |
|---|--|---|--|
| 1. ORIGINATING ACTIVITY (Corporate author) Arnold Engineering Development Center ARO, Inc., Operating Contractor Arnold Air Force Station, Tennessee | | 2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED | |
| | | 2b. GROUP N/A | |
| 3. REPORT TITLE STATIC STABILITY CHARACTERISTICS OF THE M-117 BOMB AT MACH NUMBERS FROM 0.60 TO 1.40 WITH THREE TAIL FIN CONFIGURATIONS | | | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates) April 29 to May 10, 1968 - Final Report | | | |
| 5. AUTHOR(S) (First name, middle initial, last name) M. L. Homan, ARO, Inc. | | | |
| 6. REPORT DATE July 1968 | 7a. TOTAL NO. OF PAGES 41 | 7b. NO. OF REFS 2 | |
| 8a. CONTRACT OR GRANT NO. F40600-69-C-0001 | 8a. ORIGINATOR'S REPORT NUMBER(S) AEDC-TR-68-162 | | |
| b. PROJECT NO. | 8b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) N/A | | |
| c. Program Element 6441514F | | | |
| d. | | | |
| 10. DISTRIBUTION STATEMENT This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of OOAMA (OOYEC), Hill AFB, Utah 84401. | | | |
| 11. SUPPLEMENTARY NOTES Available in DDC | | 12. SPONSORING MILITARY ACTIVITY OOAMA (OOYEC), Hill AFB, Utah 84401 | |
| 13. ABSTRACT A test was conducted in the Propulsion Wind Tunnel (16T) to determine the static stability characteristics of the M-117 Bomb with any of three tail fin configurations. Tests were made over the Mach number range of 0.6 to 1.4 for an angle-of-attack range of -3 to 19 deg, and fin orientations of 11.25 to -101.25 deg. The M-117 Bomb was statically stable for all three tail fin configurations for the Mach number range of the tests. This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of OOAMA (OOYEC), Hill AFB, Utah 84401. | | | |

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION
UNLIMITED (PER DDC-TAB-71-21, 1 Nov 71)

KEY WORDS

LINK A

LINK B

LINK C

ROLE

WT

ROLE

WT

ROLE

WT

M-117 bomb

static stability

fin configurations

wind tunnel tests

transonic flow

1. Bombs -- M-117
- 2 " -- Stability